8 Session 6: New technologies for New and Existing Buildings Allowing for Energy Conservation

Demand Controlled Ventilation — Save energy with a better operating Building

Presenter: Mr. Richard Remke, Carrier Corp.

Report Documentation Page	*Form Approved* *OMB No. 0704-0188*

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1. REPORT DATE **01 SEP 2004**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**
4. TITLE AND SUBTITLE **New technologies for New and Existing Buildings Allowing for Energy Conservation**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Carrier Corp.**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM001864, Building Energy Performance Improvement Through Advanced Technologies, Smart Organization, and Financing. Proceedings of the Industry Workshop Held in Chicago, IL on 7-8 October 2003. , The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**131**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Ventilation Control

How is ventilation provided in most buildings today?

The same way it was in 1930.

With Fixed Ventilation!

Ventilation Control

Fixed Ventilation

Building codes require ventilation rates based on cfm/person: (typically 20 cfm/person)

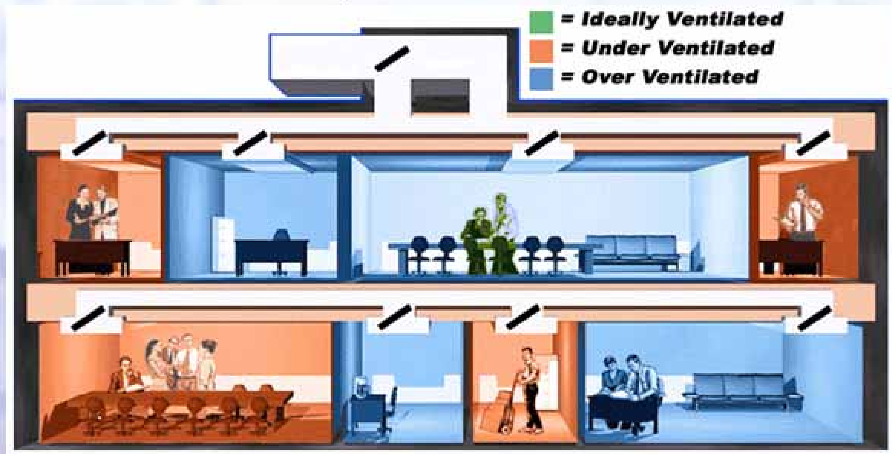
Actual Occupancy: 1 person = 500cfm

Inefficient!

Ventilation Control

Fixed Ventilation In a Multi-Zone VAV Building

Total cfm = Max occupants X 20 cfm



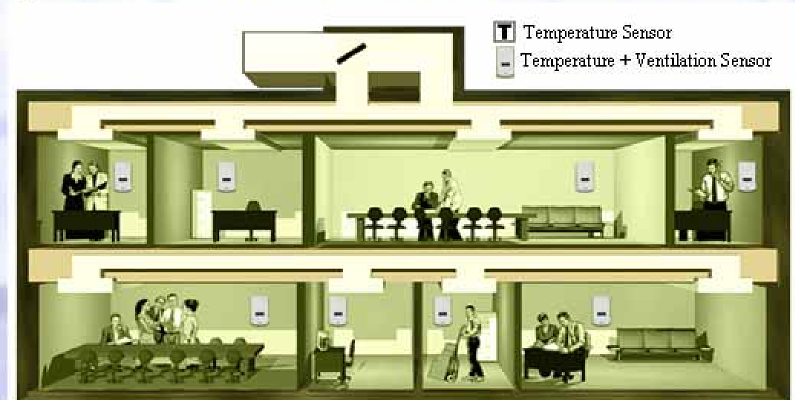
There Is No Control!

Ventilation Control

Is There A Better Way?

Ventilation Control

Temperature Control In A Multi-Zone VAV Building



- Measure In Each Zone
- Control Based On Actual Load

What if we did the same thing with ventilation?

Zone Ventilation Control

Great Idea!

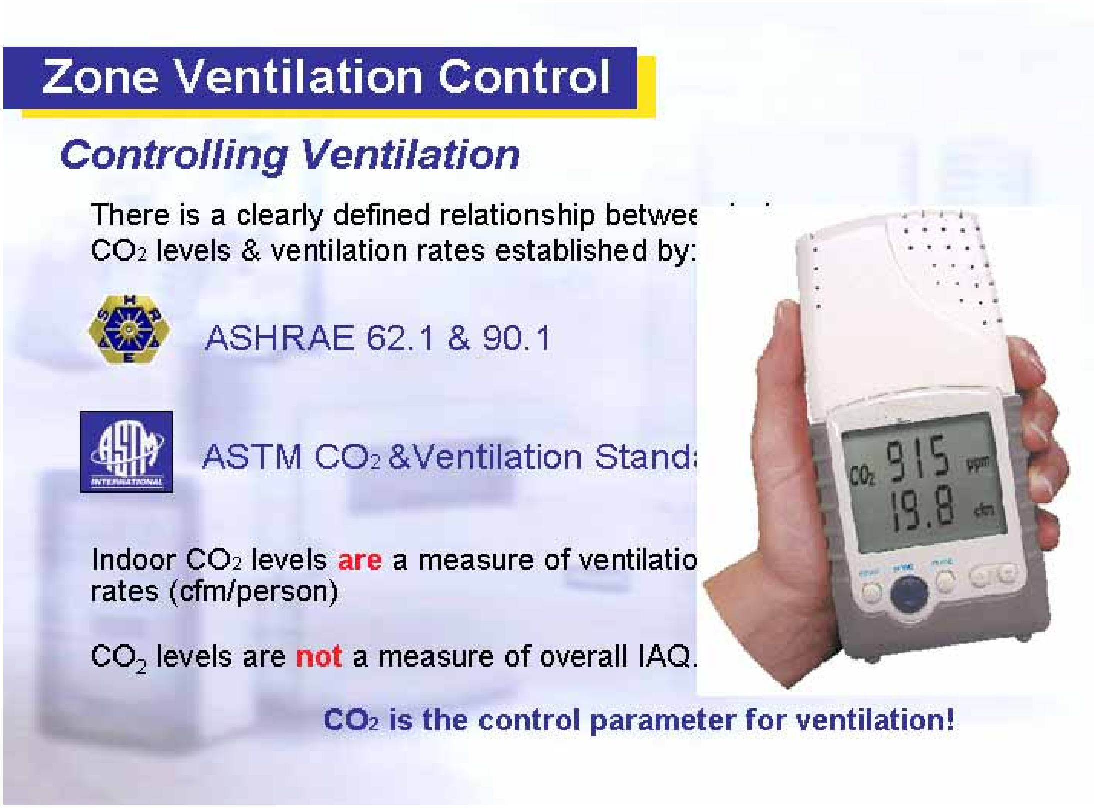
But How Does It Work?

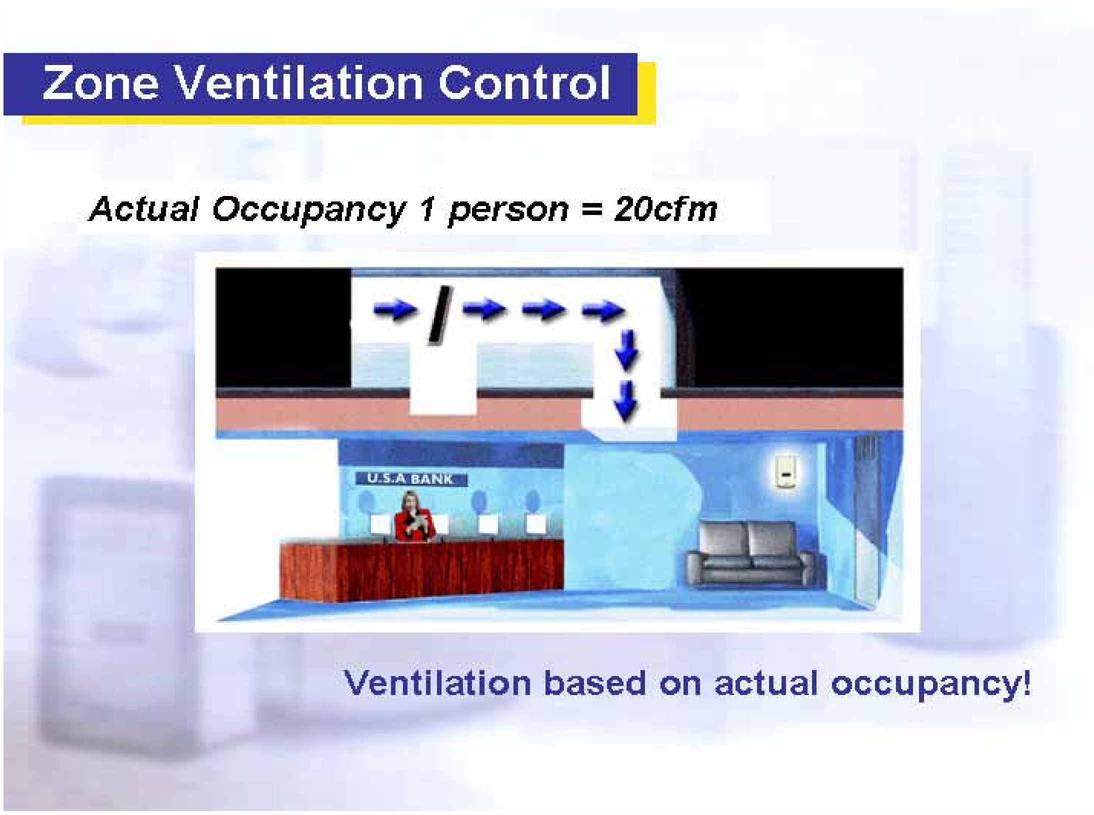
Delivers

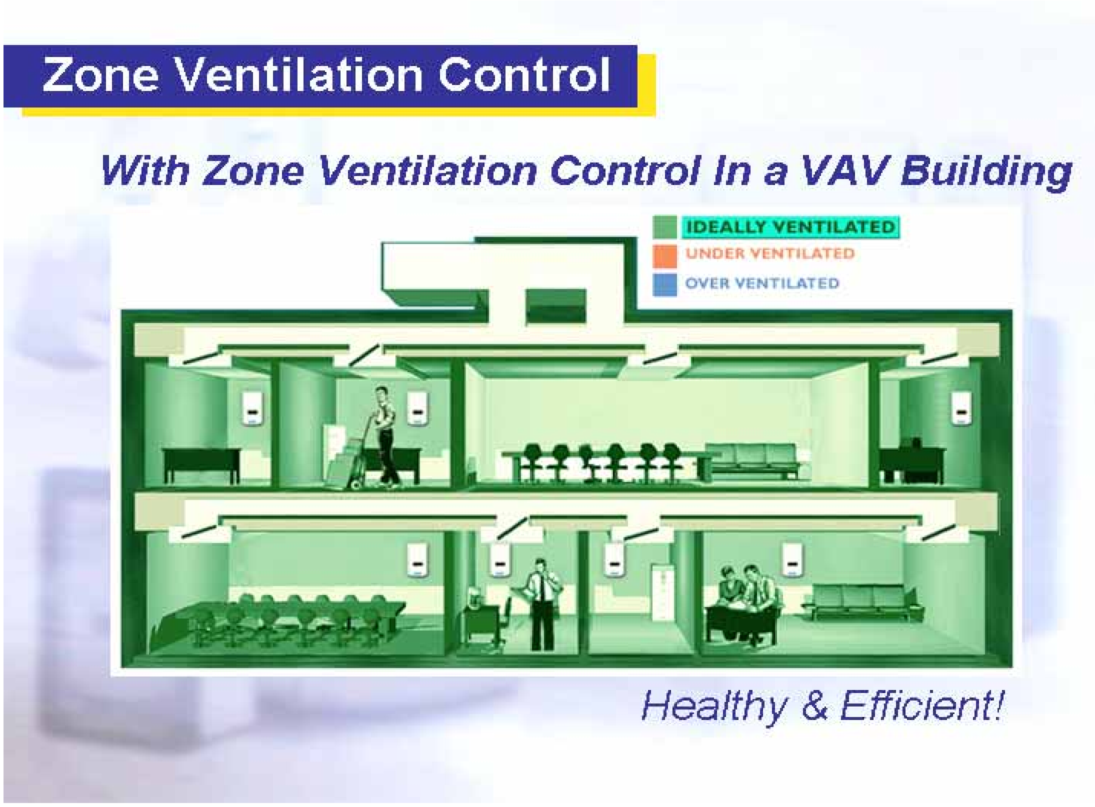
The **RIGHT** Amount of Fresh Air,

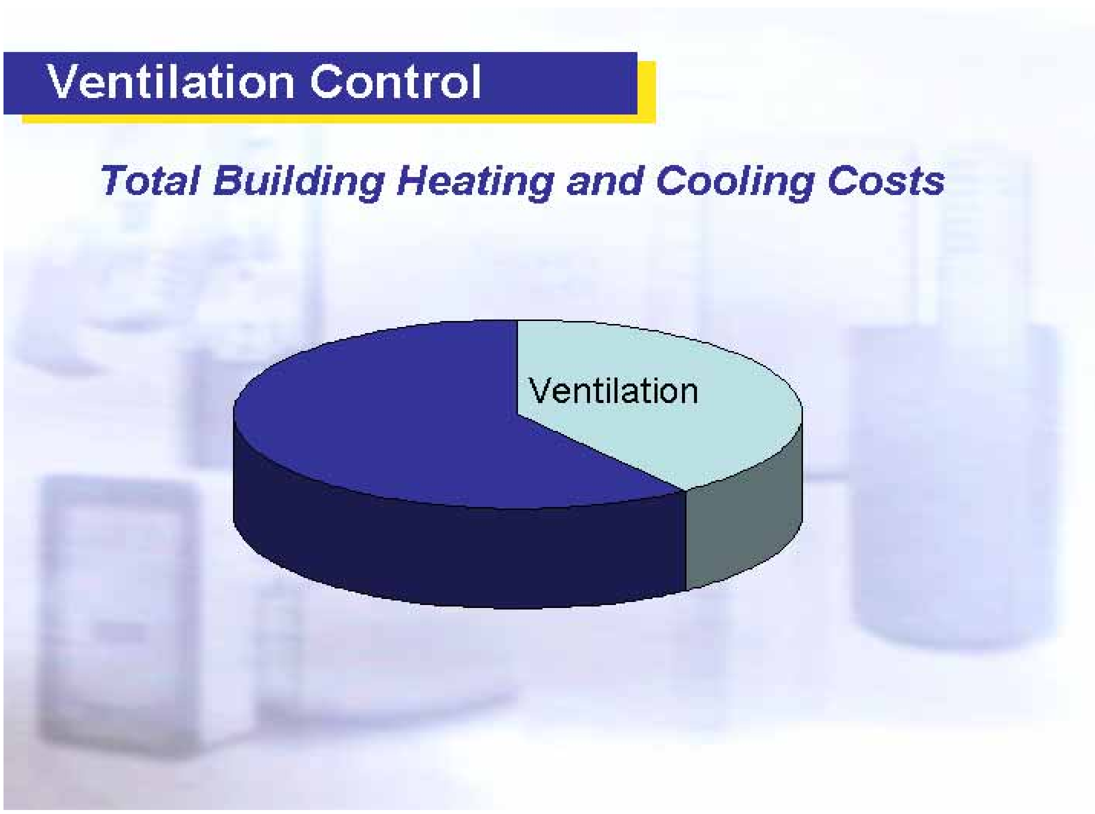
To The **RIGHT** Place,

At The **RIGHT** Time…

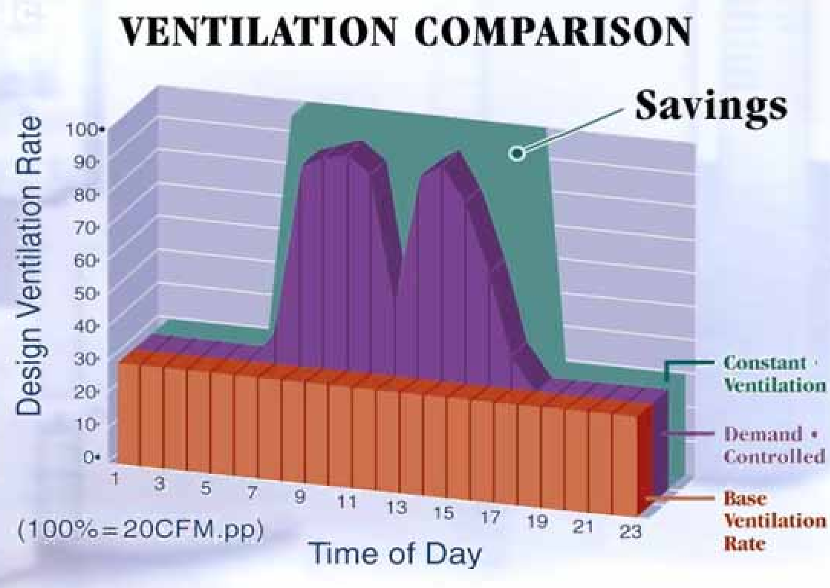

Zone Ventilation Control
Controlling Ventilation
There is a clearly defined relationship betwee
CO_2 levels & ventilation rates established by:
ASHRAE 62.1 & 90.1
ASTM CO_2 &Ventilation Stand
Indoor CO_2 levels are a measure of ventilatio
rates (cfm/person)
CO_2 levels are not a measure of overall IAQ.
CO_2
915 ppm
19.8 cfm
CO_2 is the control parameter for ventilation!


Zone Ventilation Control
Actual Occupancy 1 person = 20cfm
U.S.A BANK
Ventilation based on actual occupancy!


Zone Ventilation Control
With Zone Ventilation Control In a VAV Building
IDEALLY VENTILATED
UNDER VENTILATED
OVER VENTILATED
Healthy & Efficient!


Ventilation Control
Total Building Heating and Cooling Costs
Ventilation

Ventilation Control



Zone Ventilation Control

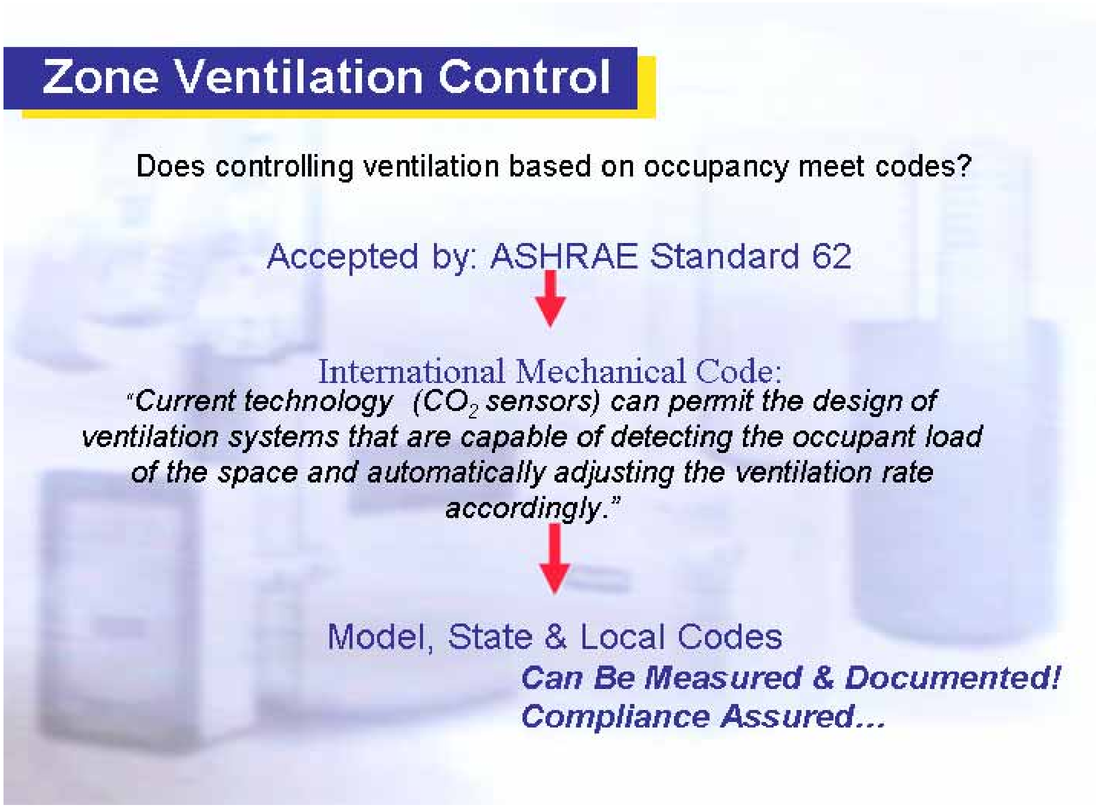
Numerous Studies Confirm That Correct Ventilation ...

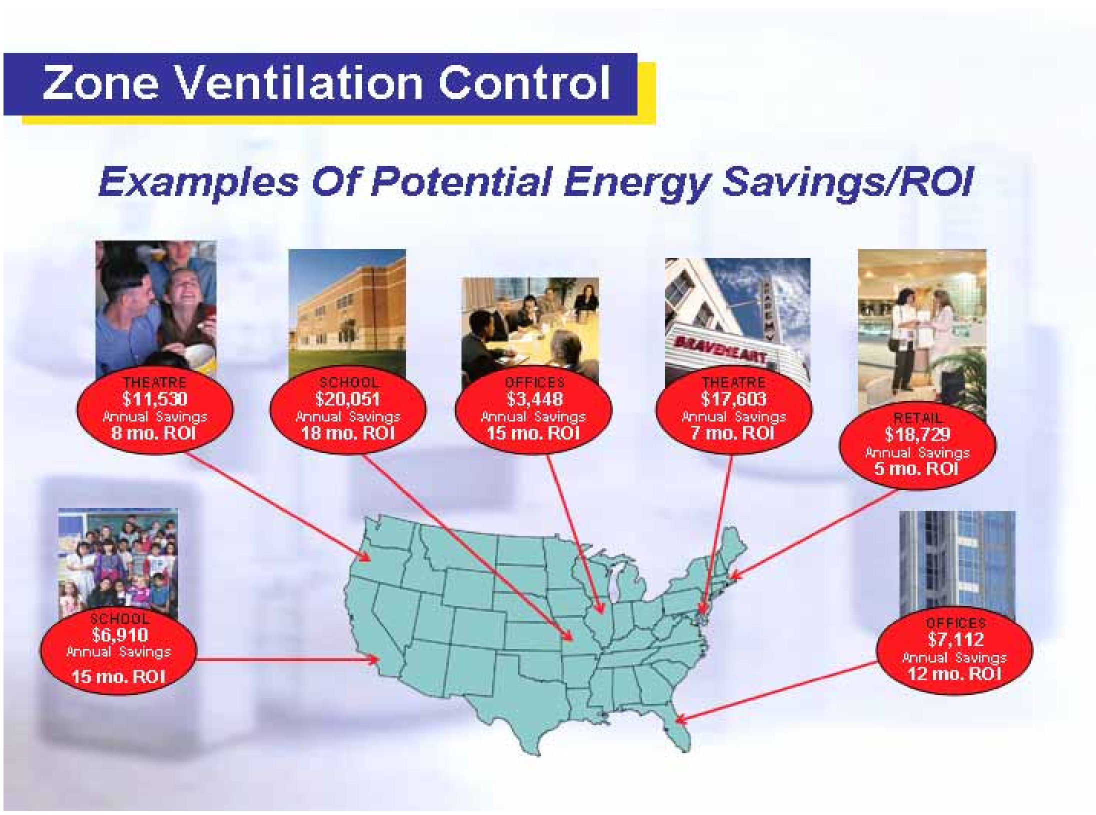
- Increases Productivity
- Improves Occupant/Customer Satisfaction
- Helps Prevent Sick Building Syndrome Health Affects

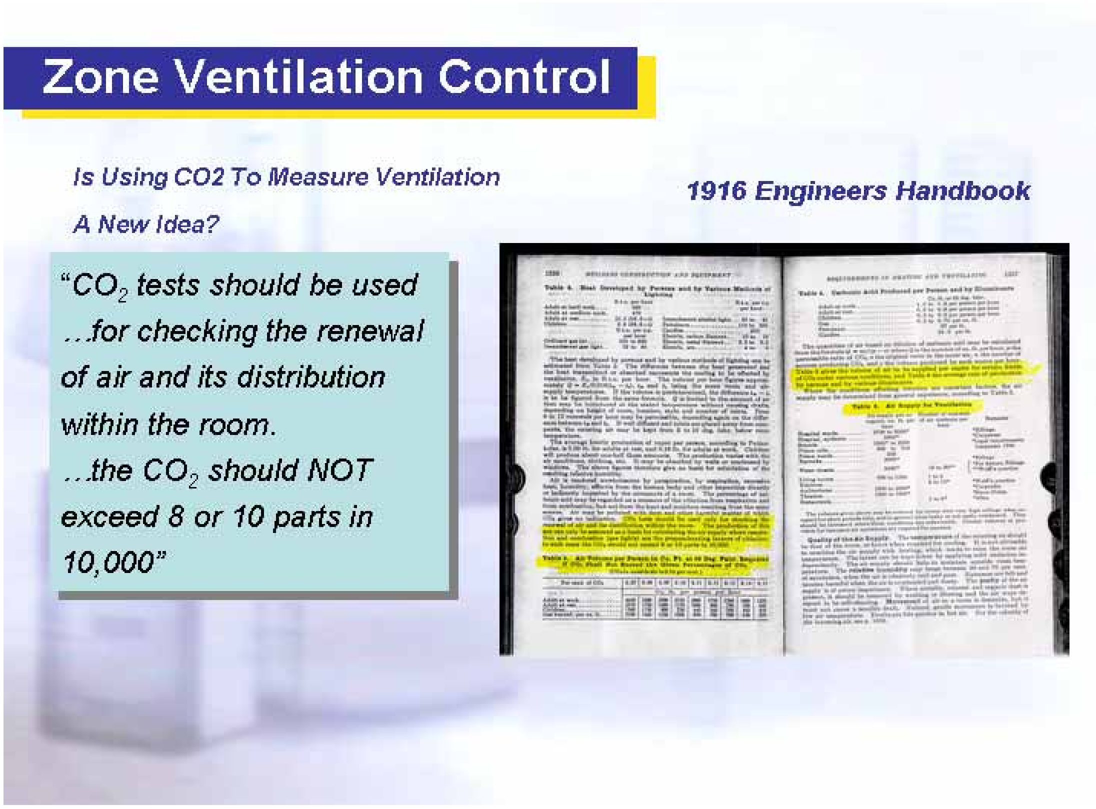
DOE/Lawrence Berkeley Labs
Indoor Environment In Schools

Pupils Health & Performance In Regard To CO_2 Concentrations

- A significant correlation was found between decreased performance and high CO_2 levels (lower ventilation rates).


Zone Ventilation Control
Does controlling ventilation based on occupancy meet codes?
Accepted by: ASHRAE Standard 62
International Mechanical Code:
"Current technology (CO2 sensors) can permit the design of ventilation systems that are capable of detecting the occupant load of the space and automatically adjusting the ventilation rate accordingly."
Model, State & Local Codes
Can Be Measured & Documented!
Compliance Assured...


Zone Ventilation Control
Examples Of Potential Energy Savings/ROI
THEATRE $11,530 Annual Savings 8 mo. ROI
SCHOOL $20,051 Annual Savings 18 mo. ROI
OFFICES $3,448 Annual Savings 15 mo. ROI
THEATRE $17,603 Annual Savings 7 mo. ROI
RETAIL $18,729 Annual Savings 5 mo. ROI
SCHOOL $6,910 Annual Savings 15 mo. ROI
OFFICES $7,112 Annual Savings 12 mo. ROI
BRAVEHEART


Zone Ventilation Control
Is Using CO2 To Measure Ventilation
A New Idea?
"CO_2 tests should be used …for checking the renewal of air and its distribution within the room.
…the CO_2 should NOT exceed 8 or 10 parts in 10,000"
1916 Engineers Handbook


Zone Ventilation Control
Why Apply It Now?
• CO_2 sensors have become cost effective and reliable.
• Building control systems can now integrate zone ventilation control.

Zone Ventilation Control

Payback Analysis

Software Analysis Tools Can Determine Potential Energy Savings and demonstrate payback

Zone Ventilation Control

Let’s review the benefits.

Zone Ventilation Control

Ensure for every zone…

- Comfort
- Health & Safety
- Compliance
- And…

Zone Ventilation Control

A Better Operating Building

- Ventilate to Actual vs. Assumed Occupancy
- Eliminate Wasteful Over-Ventilation
- Very Attractive ROI/Lower Operating Costs

Conserve Energy and Improve Indoor Air Quality through Use of Hybrid HVAC Systems.

Presenter: Mr. Leon Shapiro. ADA Systems

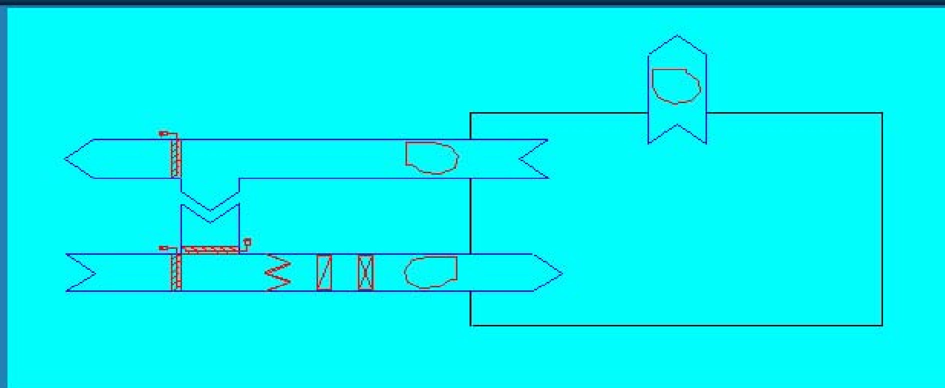
Evaporative Cooling:
Why Is This Important To You (and your clients)?

- There are external forces affecting the method and manner in which institutions and businesses provide ventilation, heating and cooling for their facilities:
  - ASHRAE Standard 62 - 2001
  - ASHRAE Standard 90.1 - 1999
  - Federal Energy Policy Act of 1992
  - LEED Certification
  - Global Climate Change Treaty
  - Current Events

Evaporative Cooling:
Why Is This Important To You (and your clients)?

- If you could, would you provide your clients/customers with an HVAC system that:
  - Supplies 100% fresh outdoor air instead of stale recirculated air
  - Uses significantly **less energy** to operate than current recirculation systems
  - Can be installed on a first cost basis equal to or less than a standard mechanical system
  - Can be **retrofitted** to their existing systems (in most cases)
  - Is **user-friendly** for maintenance personnel to operate and maintain
- If you could, you should…so let's see how….

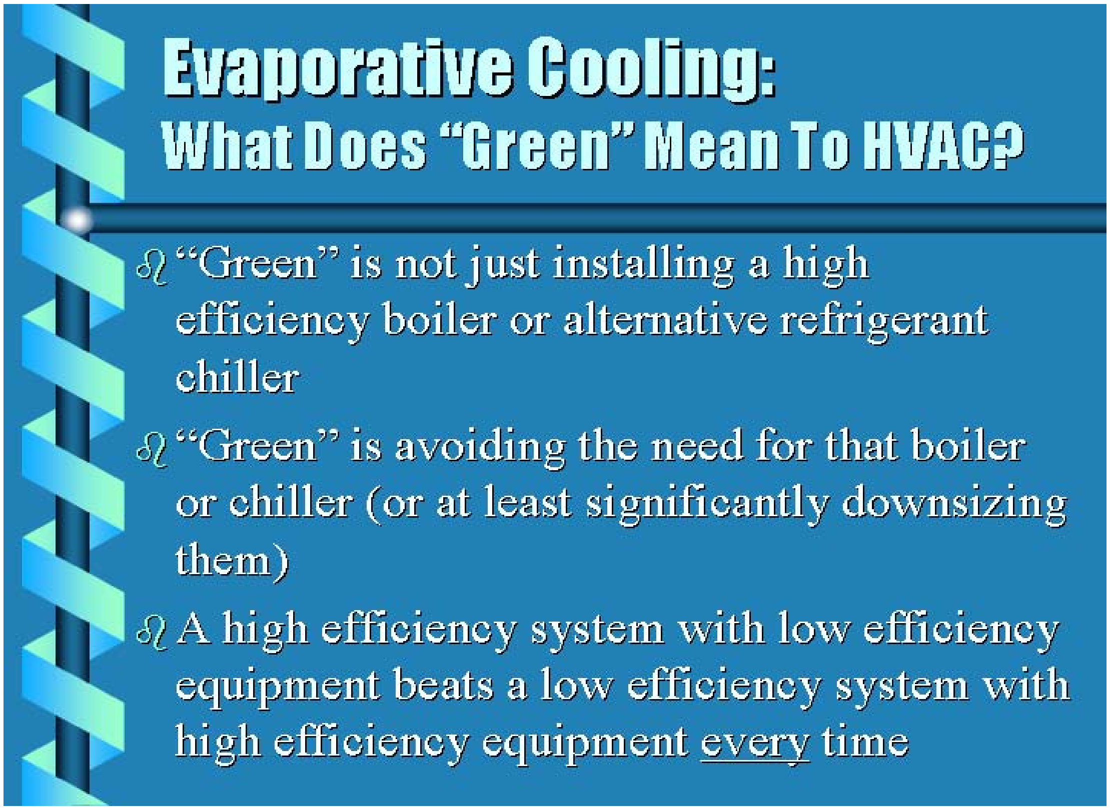
Evaporative Cooling:
Typical (Non-Evaporative) System

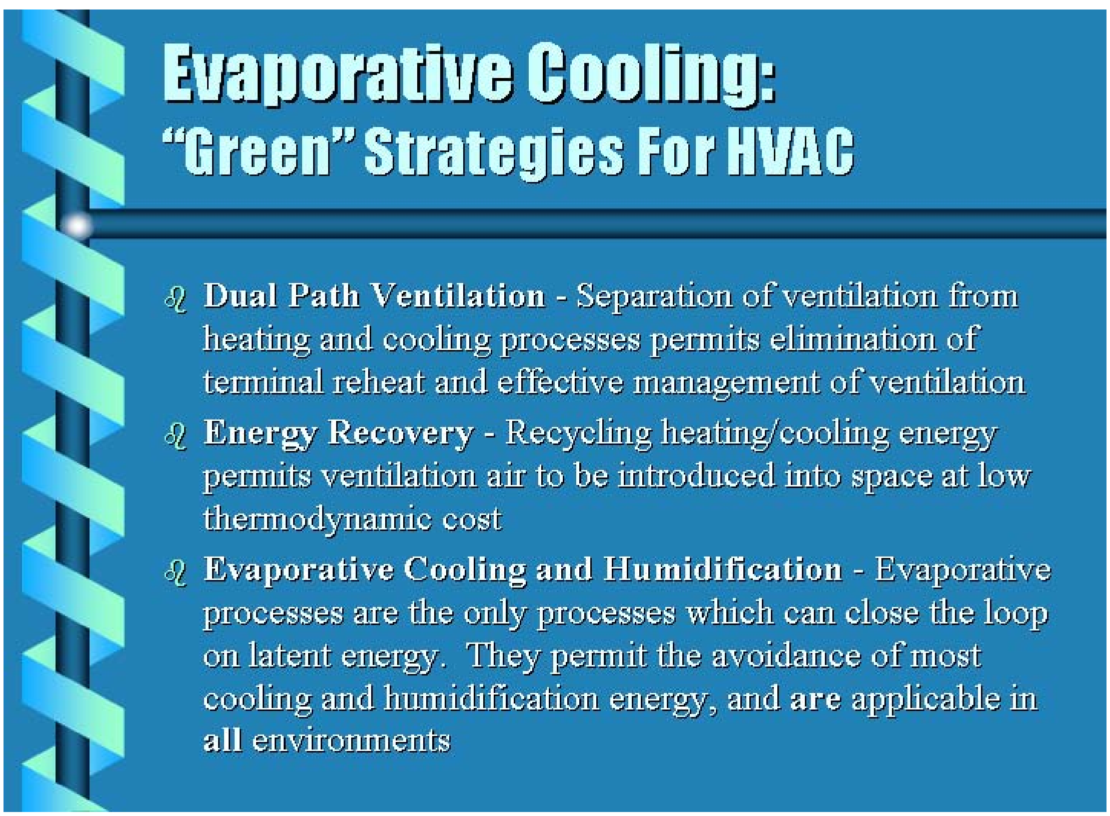


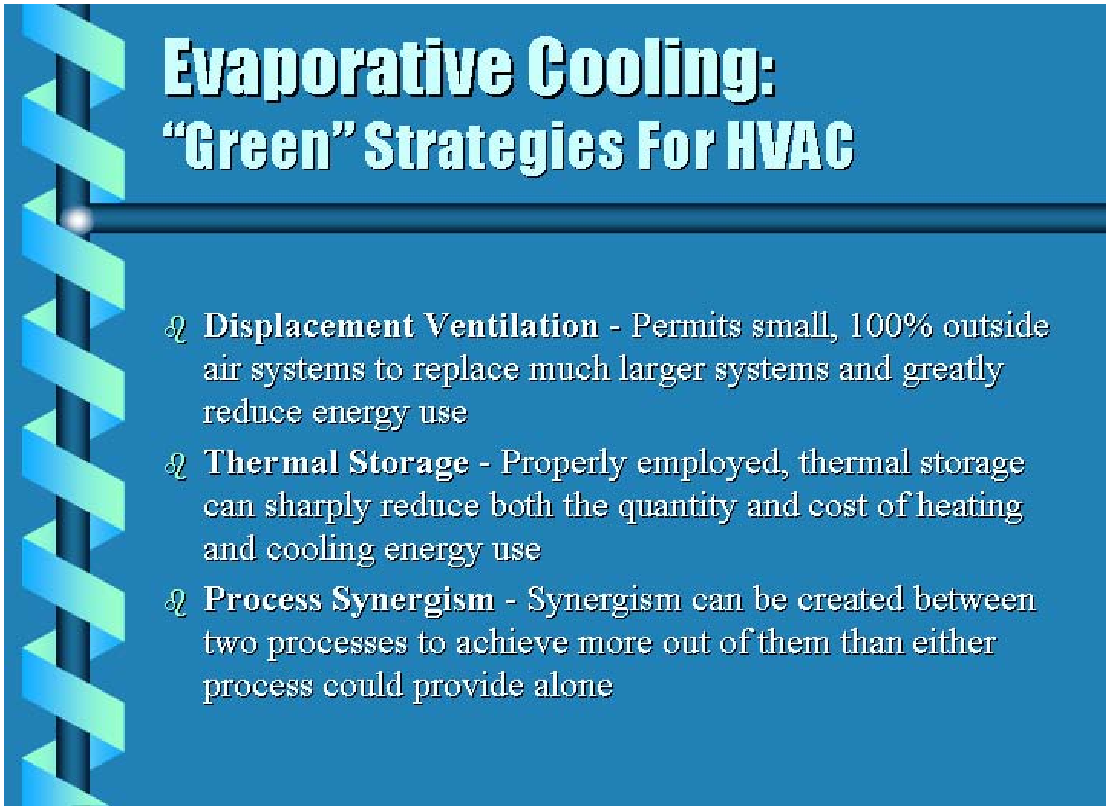
- Based on using **minimum** outside supply air, and recirculating a majority of the building return (exhaust) air

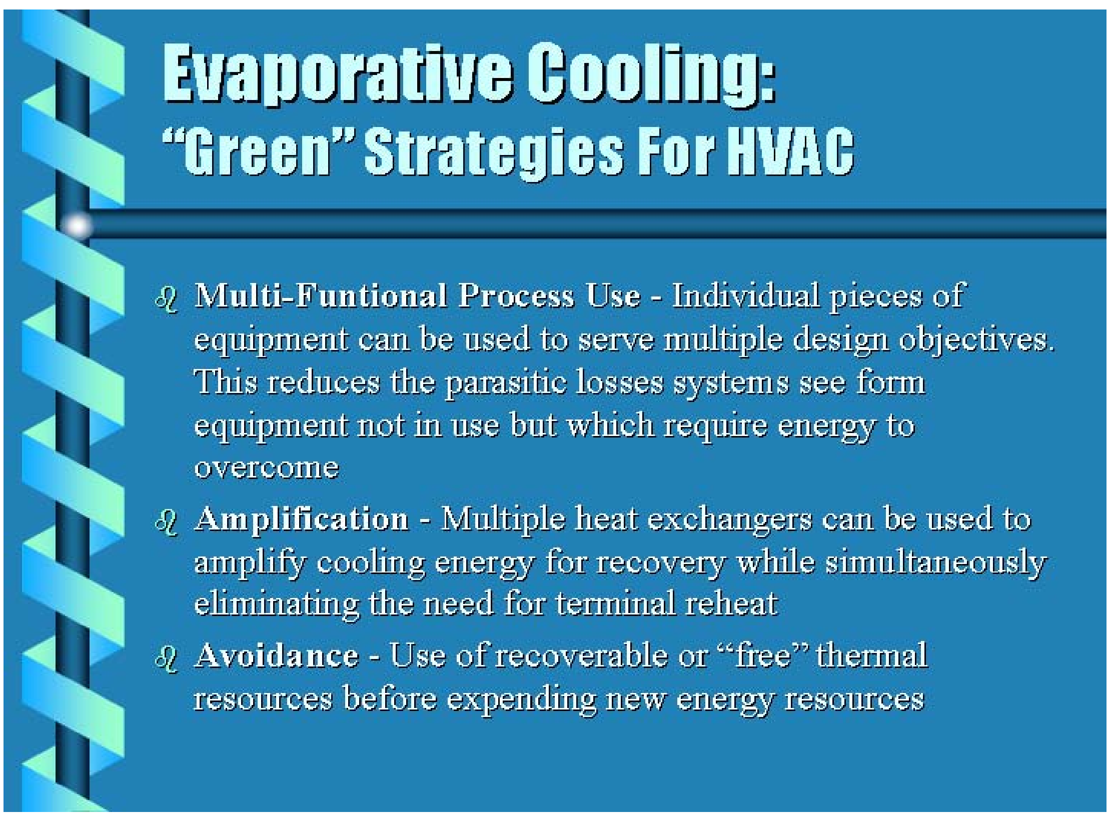
Evaporative Cooling:
Typical (Non-Evaporative) System

- Weaknesses of the Typical System:
  - Recirculation causes internally generated contaminants to become concentrated and spread to all spaces served by the system
  - Ventilation air is not managed properly
  - The process is open loop on latent heat
  - The scheme is predicated on using virgin energy to achieve psychrometric state point changes.
  - The process is predicated on using energy intensive processes

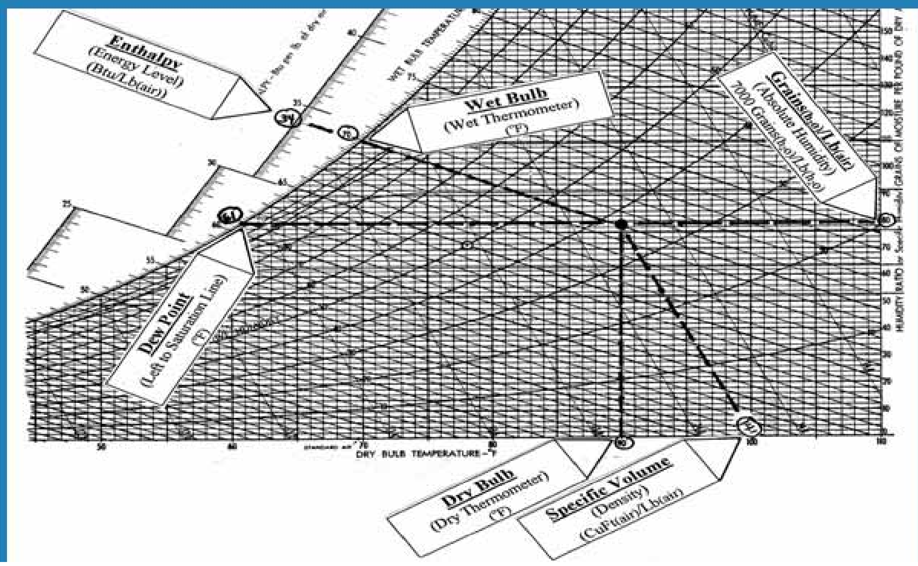

Evaporative Cooling:
What Does "Green" Mean To HVAC?
"Green" is not just installing a high efficiency boiler or alternative refrigerant chiller
"Green" is avoiding the need for that boiler or chiller (or at least significantly downsizing them)
A high efficiency system with low efficiency equipment beats a low efficiency system with high efficiency equipment every time


Evaporative Cooling:
"Green" Strategies For HVAC
Dual Path Ventilation - Separation of ventilation from heating and cooling processes permits elimination of terminal reheat and effective management of ventilation
Energy Recovery - Recycling heating/cooling energy permits ventilation air to be introduced into space at low thermodynamic cost
Evaporative Cooling and Humidification - Evaporative processes are the only processes which can close the loop on latent energy. They permit the avoidance of most cooling and humidification energy, and are applicable in all environments


Evaporative Cooling:
"Green" Strategies For HVAC
Displacement Ventilation - Permits small, 100% outside air systems to replace much larger systems and greatly reduce energy use
Thermal Storage - Properly employed, thermal storage can sharply reduce both the quantity and cost of heating and cooling energy use
Process Synergism - Synergism can be created between two processes to achieve more out of them than either process could provide alone

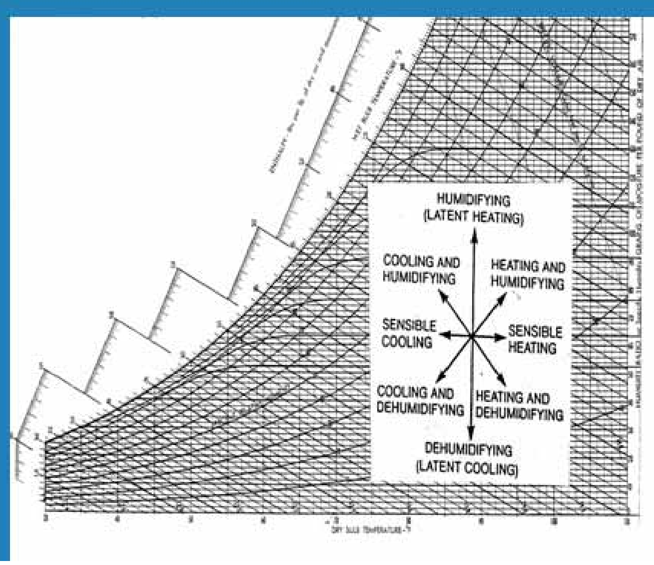

Evaporative Cooling:
"Green" Strategies For HVAC
Multi-Funtional Process Use - Individual pieces of equipment can be used to serve multiple design objectives. This reduces the parasitic losses systems see form equipment not in use but which require energy to overcome
Amplification - Multiple heat exchangers can be used to amplify cooling energy for recovery while simultaneously eliminating the need for terminal reheat
Avoidance - Use of recoverable or "free" thermal resources before expending new energy resources

Evaporative Cooling:
Understanding The Psychrometric Chart



Evaporative Cooling:
Understanding The Psychrometric Chart

- All psychrometric processes can be seen as a combination of:
  - Cooling
  - Heating
  - Humidifying
  - Dehumidifying



Evaporative Cooling: Multiple Forms and Technologies

- Evaporative cooling technologies form the backbone of energy efficient hybrid HVAC systems
- There are 2 forms of evaporative cooling
  - **Direct**
    - Draws warm air through a wetted media
  - **Indirect**
    - Utilizes a heat exchanger to separate the supply air from the water used for evaporation
    - Uses a secondary air stream to reject heat from the evaporation process

Evaporative Cooling: Direct Evaporative Cooling Cycle

"Effectiveness" is defined by the following equation:

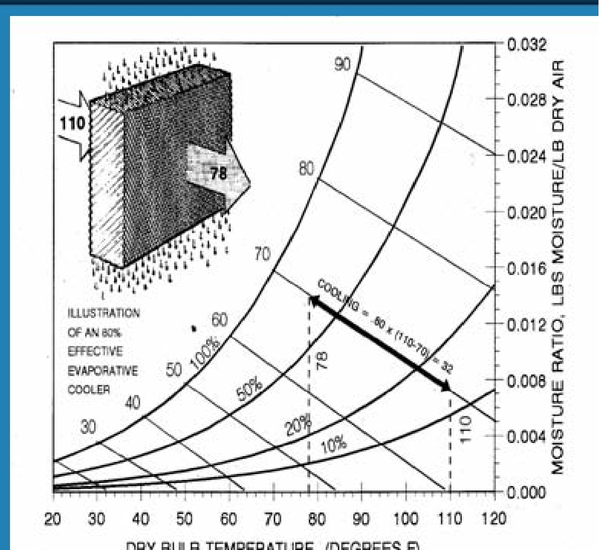
$$E = (TI_{db} - TD_{db}) \div (TI_{db} - TI_{wb})$$

"Discharge Temperature" can be determined by the following equation:

$$TD_{db} = TI_{db} - [E \times (TI_{db} - TI_{wb})]$$

Factors affecting effectiveness are:

- Type of Media
- Depth of Media
- Face Velocity



Evaporative Cooling:
Indirect Evaporative Cooling Cycle

"Effectiveness" is defined by the following equation:

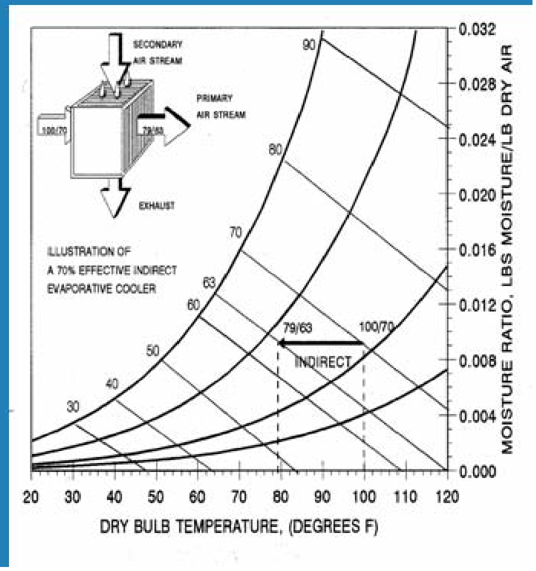
$E = (TI_{db} - TD_{db}) \div (TI_{db} - TIS_{wb})$

"Discharge Temperature" can be determined by the following equation:

$TD_{db} = TI_{db} - [E \times (TI_{db} - TIS_{wb})]$

Factors affecting effectiveness are:

- Type of Heat Exchanger
- Supply Air Flow Through Exchanger
- Secondary Air Flow
- Use of Outside Air vs. Building Exhaust as the Secondary Air Source



Evaporative Cooling:
Advantages of Indirect Cooling/Heating

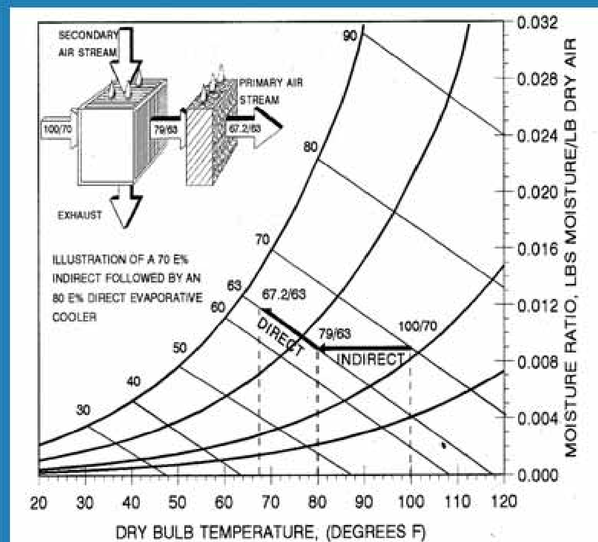
- Provides a sensible cooling process
- Extends the effective Economizer range
- Meets base cooling loads under part load conditions most of the time
- Can be used to provide winter energy (heat) recovery
- Makes 100% outside air applications more economical than recirculation systems
- Reduces the need for refrigeration

Evaporative Cooling:

Indirect/Direct Evaporative Cooling Cycle

An Indirect / Direct combination will provide cooler air than either process by itself

In certain climates this combined process alone will provide true “comfort cooling”



Evaporative Cooling:

Performance Chart (Low Wet Bulb Area)

SACRAMENTO, CALIFORNIA

Performance of Evaporative Cooling and Heat Recovery Technologies

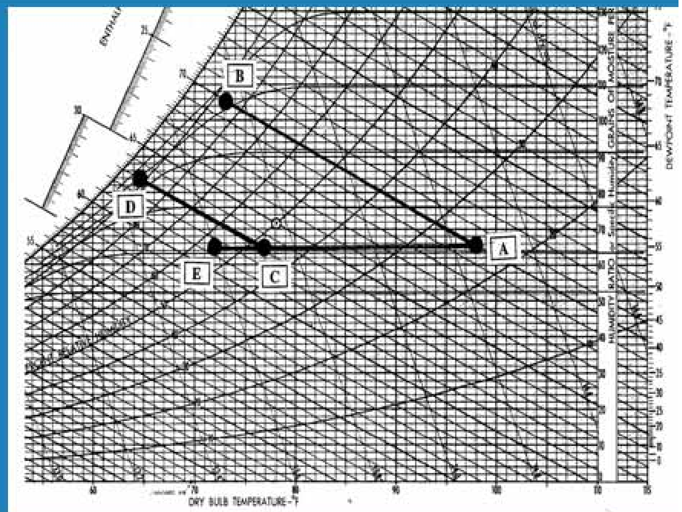
Ambient OSA DB/WB	Hours/ Year	INDIRECT OSA as Secondary Air	INDIRECT Bldg. Exhaust as Secondary Air	DIRECT	INDIRECT DIRECT OSA as Secondary Air
107/70	7	79/61	74/59	74/70	63/61
102/70	59	78/63	73/61	73/70	65/63
97/68	144	75/61	72/60	71/68	62/61
92/66	242	72/60	70/59	69/66	61/60
87/65	301	70/59	69/59	67/65	60/59
82/63	397	68/58	68/58	65/63	59/58
77/61	497	65/57	66/57	63/61	58/57
72/59	641	62/55	65/56	60/59	56/55
67/57	821	60/54	64/56	58/57	55/54
62/54	1086	56/52	63/55	55/54	53/52

The above discharge temperatures (°F) are based on the following:

1. 75% Indirect Evaporative Effectiveness
2. 90% Direct Evaporative Effectiveness
3. 50% Heat Recovery Effectiveness
4. 75°F Building Exhaust Dry Bulb Temperature (Heat Recovery)
5. 63°F Building Exhaust Wet Bulb Temperature (Cooling)
6. DB = Dry Bulb Temperature
7. WB = Wet Bulb Temperature
8. OSA = Outside Air

Evaporative Cooling:
Psychrometric Chart (Low Wet Bulb)

- Sacramento, CA
- A: Outside air 98/70
- B: Direct 73/70
- C: Indirect (OSA) 77/63
- D: Indirect/Direct 64.5/63
- E: Indirect (bldg. exhaust) 72/62



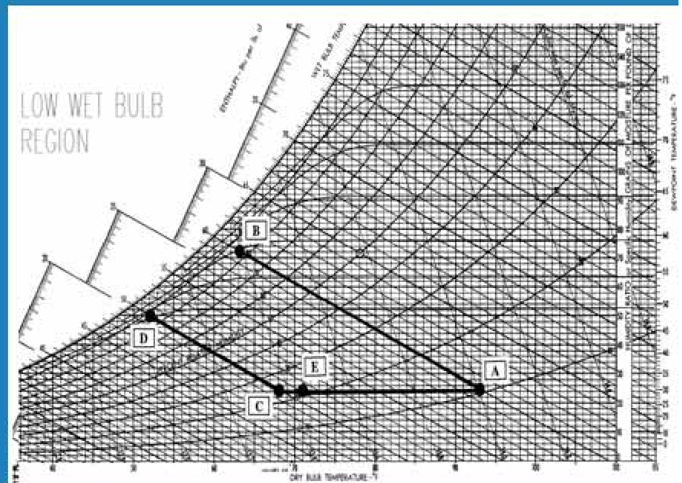
Evaporative Cooling:
Performance Chart (Low Wet Bulb Area)

RENO, NEVADA

Ambient OSA DB/WB	Hours/ Year	INDIRECT OSA as Secondary Air	IND/DIRECT OSA as Secondary Air	DIRECT	HEAT RECOVERY
97/60	18	69/50	52/50	64/60	
92/60	127	68/51	53/51	63/60	
87/58	297	65/50	52/50	61/58	
82/56	339	63/49	59/49	59/56	
77/55	390	61/49	50/49	57/55	
72/53	397	58/48	49/48	55/53	
67/50	436	54/45	46/45	52/50	
62/48	720	52/44	45/44	49/48	68.5
57/46	783	49/43	44/43	47/46	66
52/43	871				63.5
47/40	922				61
42/36	714				58.5
37/33	873				56
32/29	762				53.5
27/25	550				51
22/21	310				48.5
17/16	246				46
12/11	74				43.5
7/6	10				41
2	2				38.5
-2	3				36.5
-7	6				34

Evaporative Cooling:
Psychrometric Chart (Low Wet Bulb)

- *Reno, NV
- *A: Outside air 93/60
- *B: Direct 63/60
- *C: Indirect (OSA) 68/50
- *D: Indirect/Direct 52/50
- *E: Indirect (building exhaust) 71/51



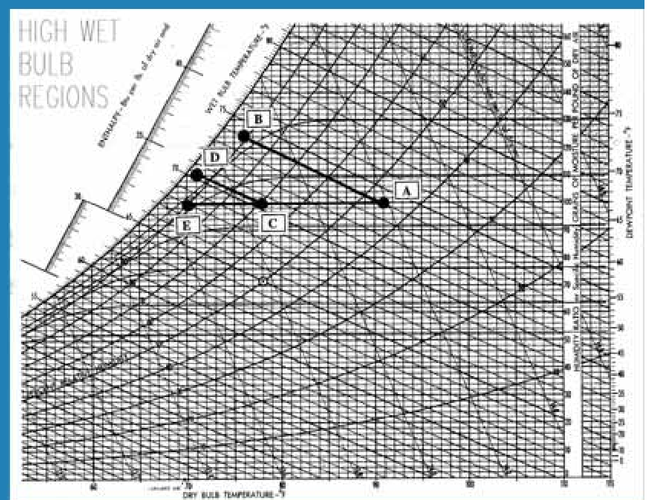
Evaporative Cooling:
Performance Chart (High Wet Bulb Area)

CHICAGO, ILLINOIS

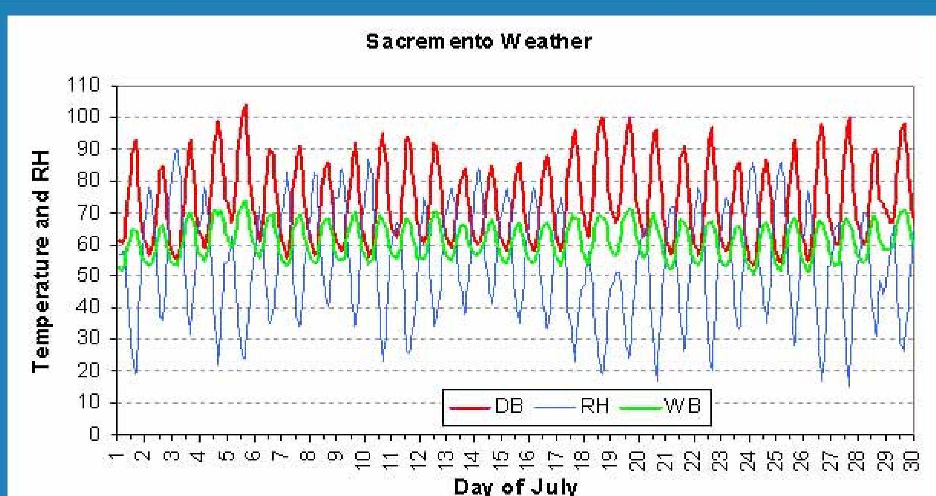
Ambient OSA DB/WB	Hours/ Year	INDIRECT OSA as Secondary Air	INDIRECT Bldg. Exhaust as Secondary Air	DIRECT	INDIRECT DIRECT OSA as Secondary Air	HEAT RE-COVERY
97/76	6	81/71	71/69	78/76	72/71	
92/74	58	78/70	70/68	76/74	71/70	
87/72	165	76/69	69/67	73/72	70/69	
82/70	324	73/67	68/66	71/70	68/67	
77/67	487	70/65	67/64	68/67	66/65	
72/64	681	66/62	65/62	65/64	63/62	
67/61	759	62/59	64/60	62/61	60/58	
62/57	700	60/56		58/57	57/55	
57/52	604	53/50		53/52	51/49	
52/47	581					66
47/43	565					64
42/38	572					62
37/34	725					60
32/30	869					58
27/25	589					56
22/21	371					54
17/16	231					52
12/11	164					50
7/6	115					48
2/1	89					46
-3	53					44
-8	27					42
-13	11					40
-17	2					38

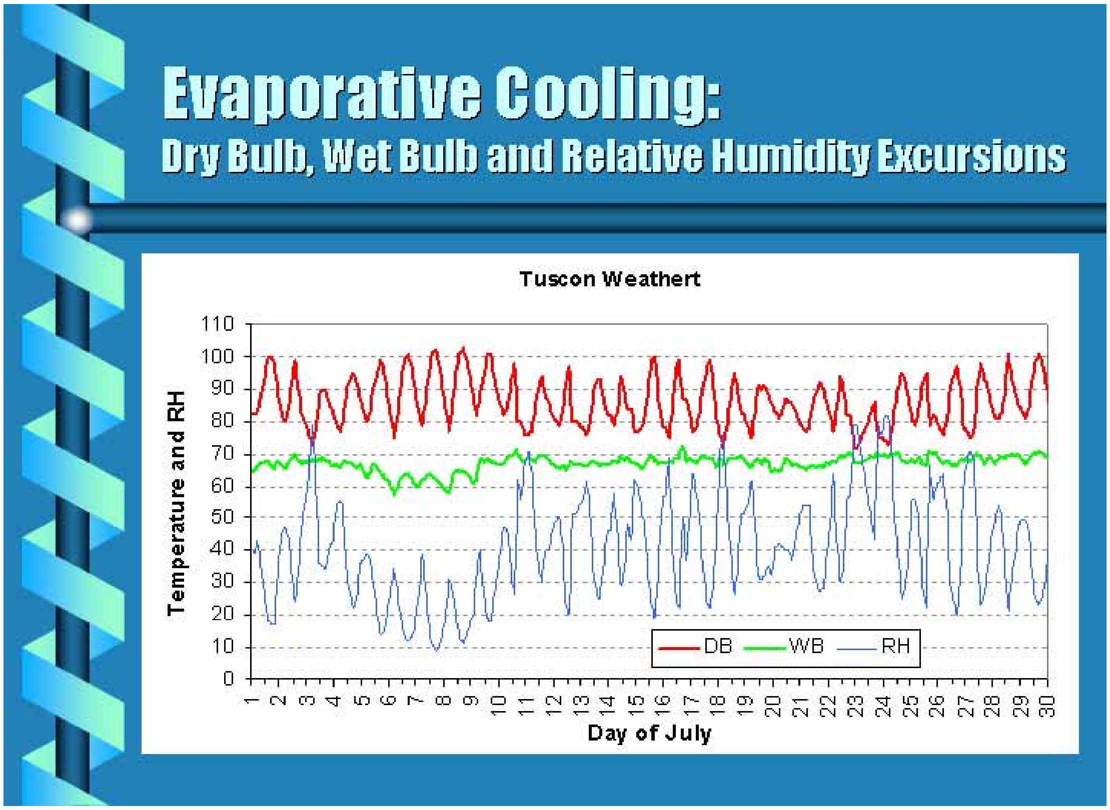
Evaporative Cooling:
Psychrometric Chart (High Wet Bulb)

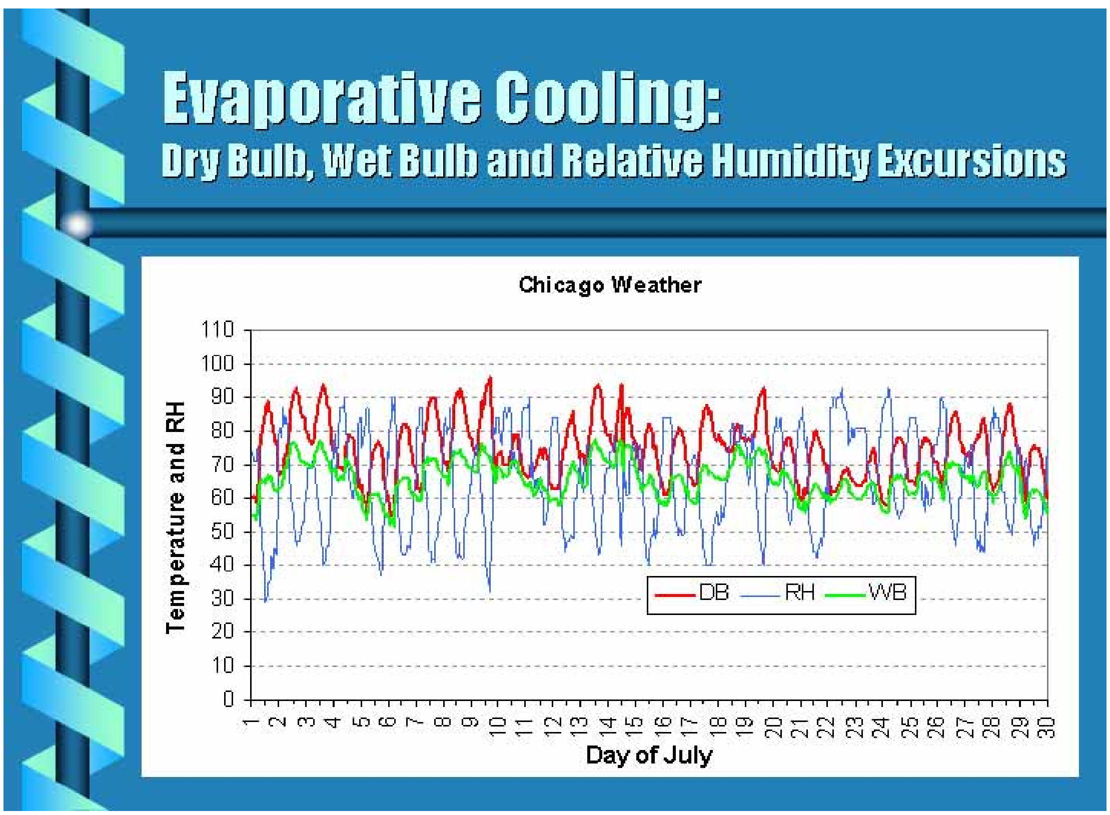
- Chicago, IL
- A: Outside air 91/74
- B: Direct 76/74
- C: Indirect (OSA) 78/70
- D: Indirect/Direct 71/70
- E: Indirect (building exhaust) 70/68



Evaporative Cooling:
Dry Bulb, Wet Bulb and Relative Humidity Excursions




Evaporative Cooling:
Dry Bulb, Wet Bulb and Relative Humidity Excursions
Tuscon Weathert
Temperature and RH
Day of July
DB WB RH
0 10 20 30 40 50 60 70 80 90 100 110
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30


Evaporative Cooling:
Dry Bulb, Wet Bulb and Relative Humidity Excursions
Chicago Weather
Temperature and RH
Day of July
DB RH WB
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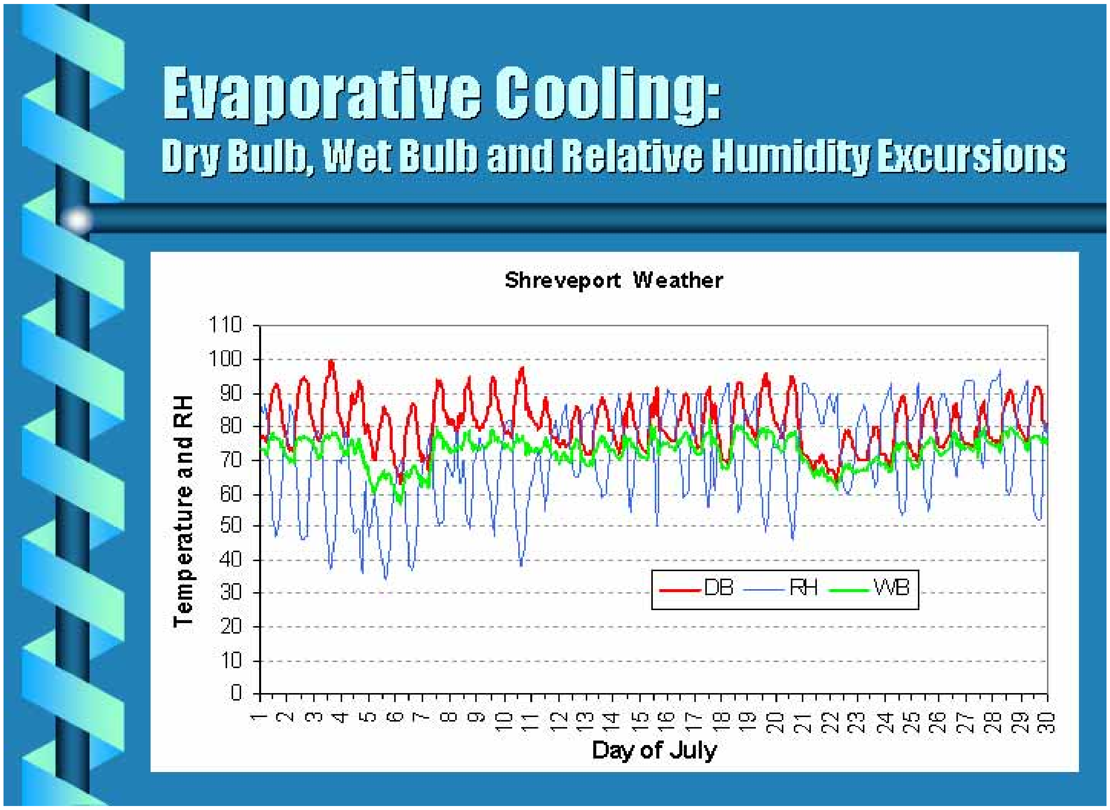
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30


Evaporative Cooling:
Dry Bulb, Wet Bulb and Relative Humidity Excursions
Shreveport Weather
Temperature and RH
110
100
90
80
70
60
50
40
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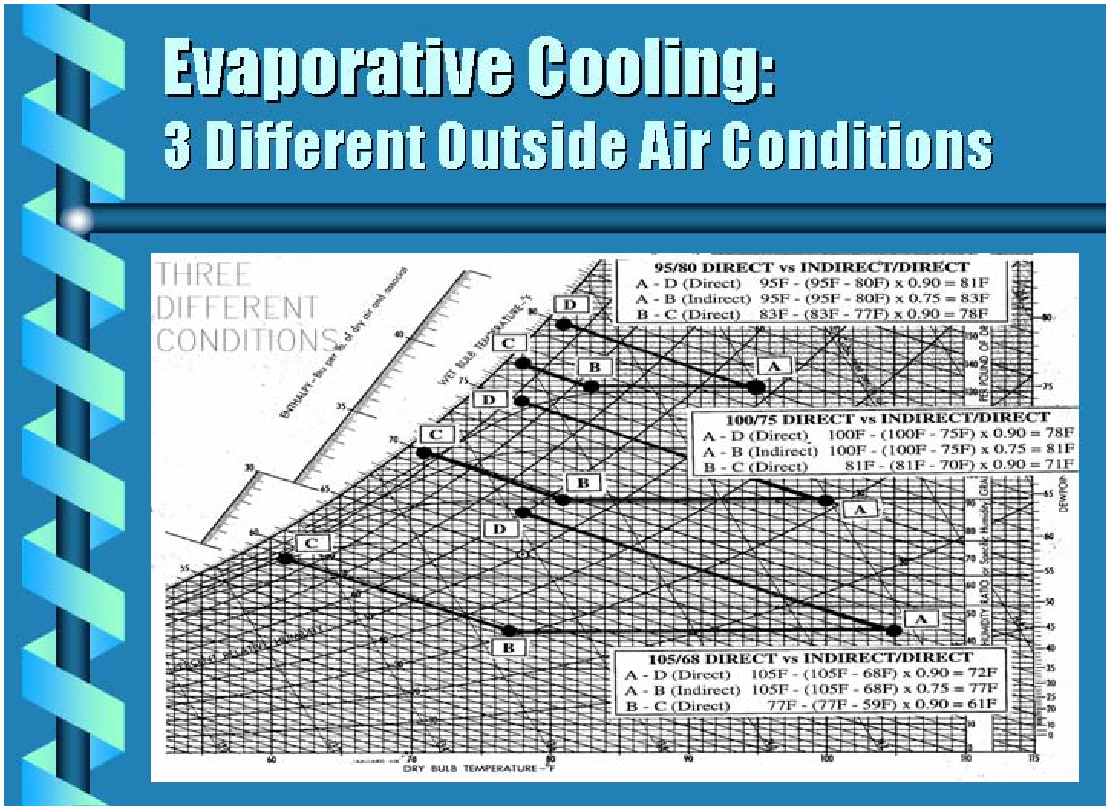
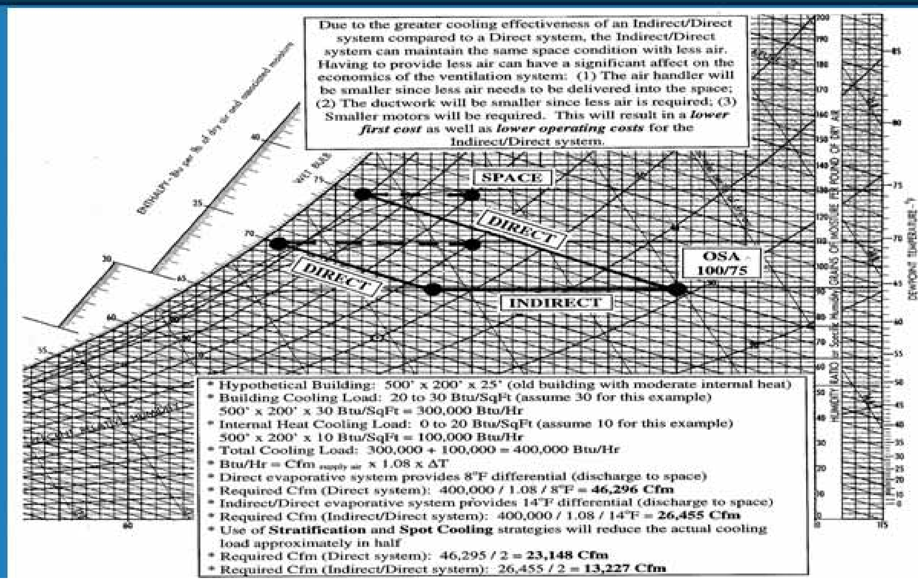
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Day of July
DB
RH
WB


Evaporative Cooling:
3 Different Outside Air Conditions
THREE DIFFERENT CONDITIONS
95/80 DIRECT vs INDIRECT/DIRECT
A - D (Direct) 95F - (95F - 80F) x 0.90 = 81F
A - B (Indirect) 95F - (95F - 80F) x 0.75 = 83F
B - C (Direct) 83F - (83F - 77F) x 0.90 = 78F
100/75 DIRECT vs INDIRECT/DIRECT
A - D (Direct) 100F - (100F - 75F) x 0.90 = 78F
A - B (Indirect) 100F - (100F - 75F) x 0.75 = 81F
B - C (Direct) 81F - (81F - 70F) x 0.90 = 71F
105/68 DIRECT vs INDIRECT/DIRECT
A - D (Direct) 105F - (105F - 68F) x 0.90 = 72F
A - B (Indirect) 105F - (105F - 68F) x 0.75 = 77F
B - C (Direct) 77F - (77F - 59F) x 0.90 = 61F
DRY BULB TEMPERATURE – °F

Evaporative Cooling:
Comparison of Direct vs Indirect/Direct



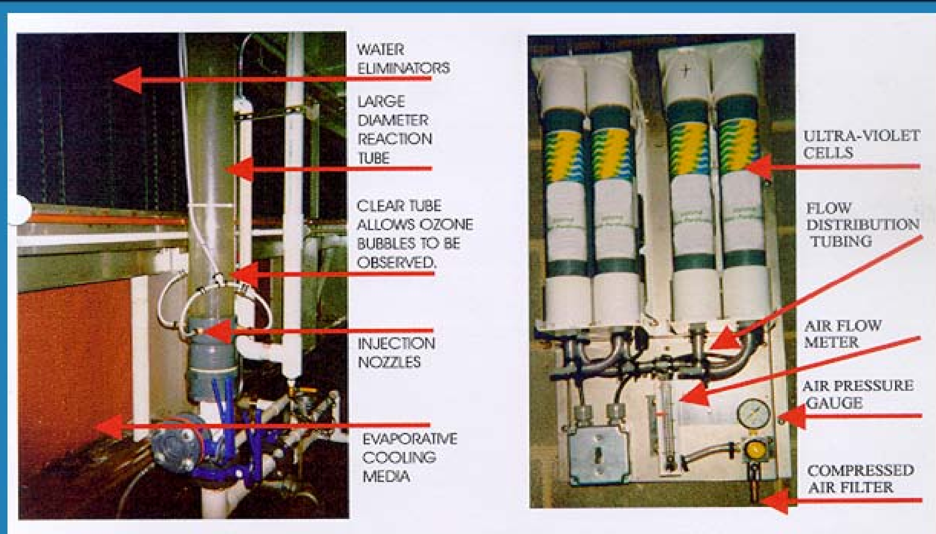
Evaporative Cooling:
Typical Direct Evaporative Module

- Design Features of a Good Evaporative System
  - Stainless Steel
  - Bottom Drain
  - Bleed and/or Purge
  - Pre-filters
  - Hood/Louvers
  - Mist Eliminators
  - Microbial Control
    - Dry the Pads
    - Run Fan After Pump Shuts Off
    - Flush Pads
    - Ozonation

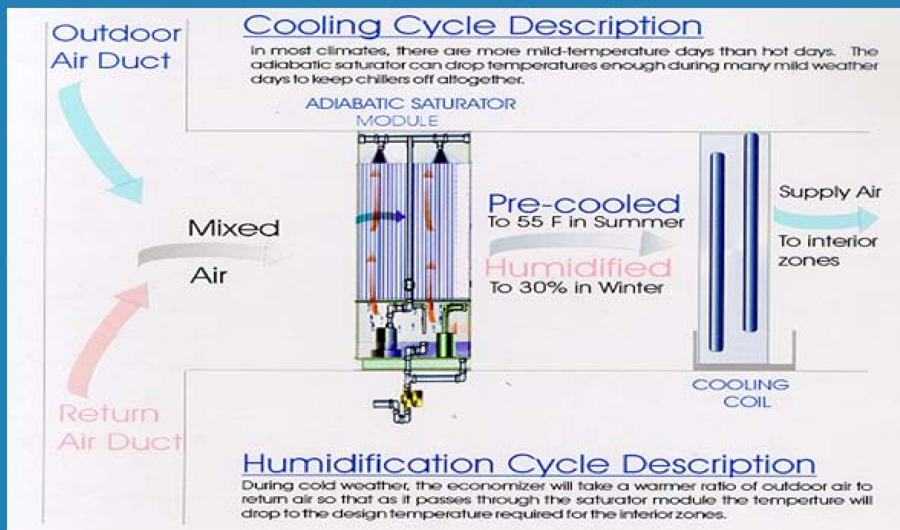
Evaporative Cooling
Microbial Control

- There have been no cases of Legionnaire's Disease associated with evaporative coolers (see ASHRAE Guideline 12-2000)
- There are significant differences between evaporative coolers and cooling towers
- The ***Bio-Terminator™*** ozonation system was designed for active microbial control
- Ozone (O_3) is an extremely powerful oxidizer
  - Highly soluble in water
  - Very short half life
  - Benign at low levels

Evaporative Cooling:
Microbial Control



Evaporative Cooling:
Cooling And Humidification

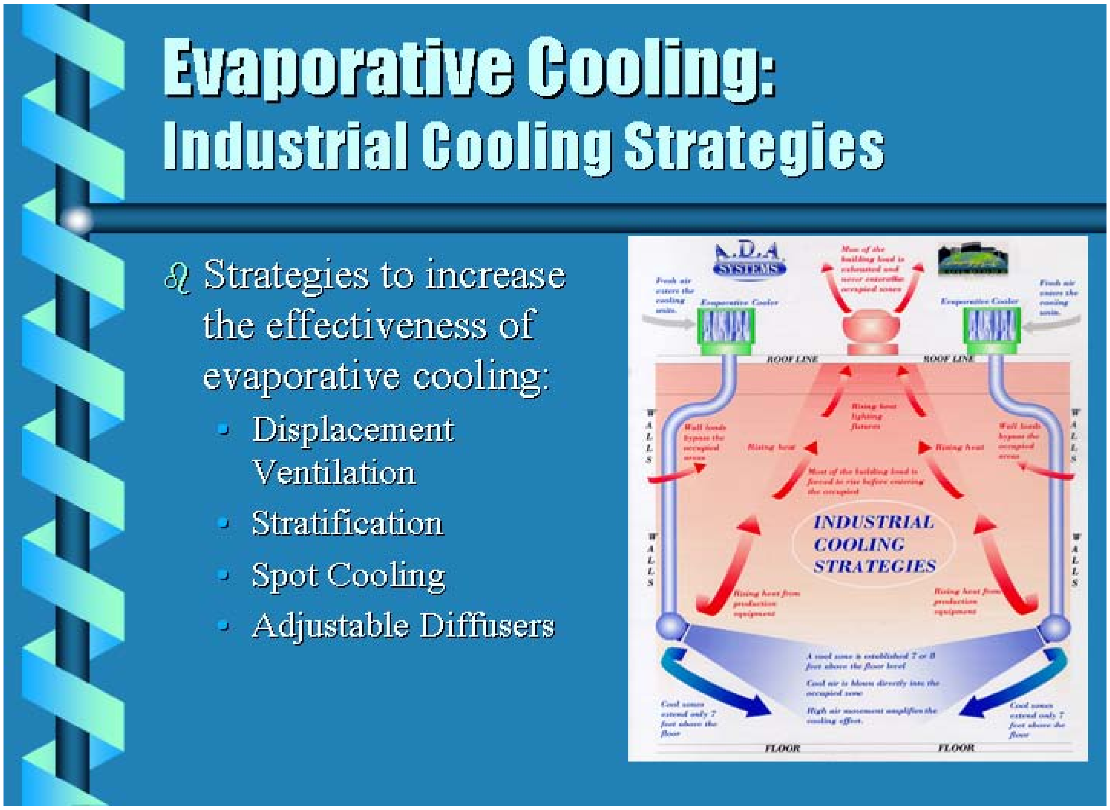


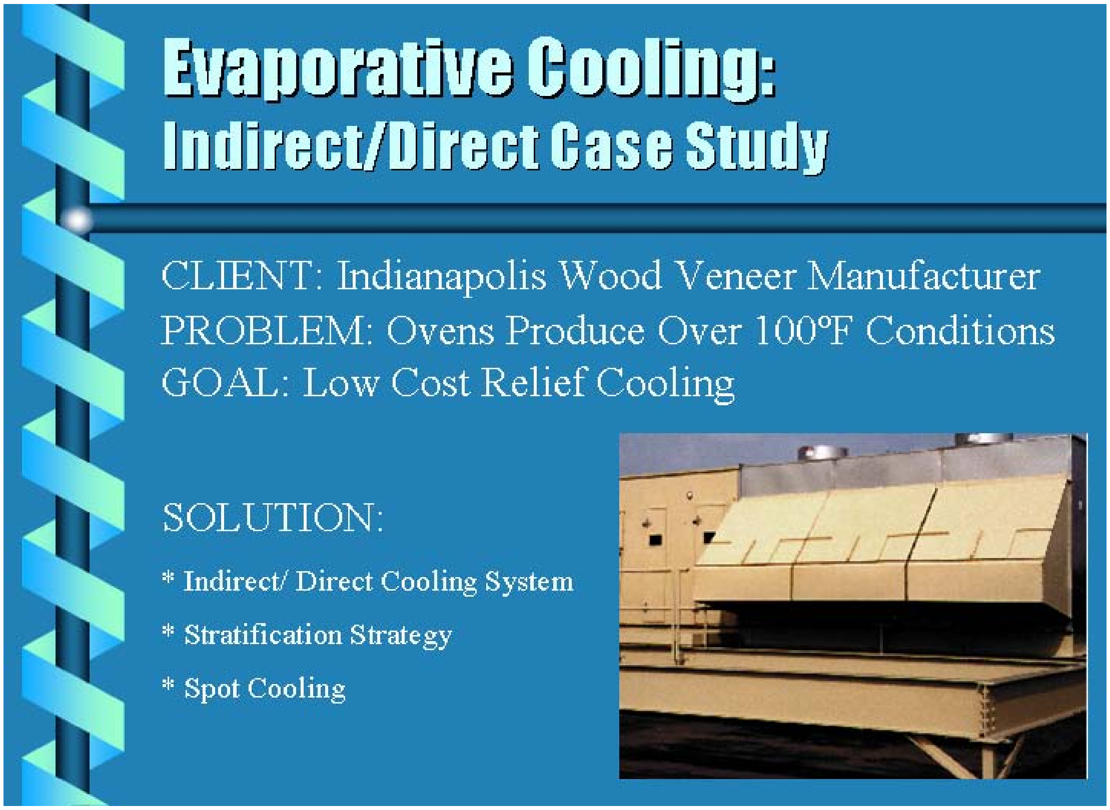
Evaporative Cooling:
What Are The Adverse Affects Of Heat?

NASA Report CR-1205-1 (Heat Stress)

Effective Temperature	75	80	85	90	95	100	105
Loss in Work Output	3%	8%	18%	29%	45%	62%	79%
Loss in Accuracy	-	5%	40%	300%	700%	-	-

- ACGIH has established guidelines for reducing heat stress, including:
  - Increased rates of ventilation
  - **Evaporative cooling of ventilation air**
  - Displacement ventilation with stratification
  - Increased fluid intake


Evaporative Cooling:
Industrial Cooling Strategies
Strategies to increase the effectiveness of evaporative cooling:
Displacement Ventilation
Stratification
Spot Cooling
Adjustable Diffusers
ROOF LINE
ROOF LINE
INDUSTRIAL COOLING STRATEGIES
FLOOR
FLOOR


Evaporative Cooling:
Indirect/Direct Case Study
CLIENT: Indianapolis Wood Veneer Manufacturer
PROBLEM: Ovens Produce Over 100°F Conditions
GOAL: Low Cost Relief Cooling
SOLUTION:
* Indirect/ Direct Cooling System
* Stratification Strategy
* Spot Cooling

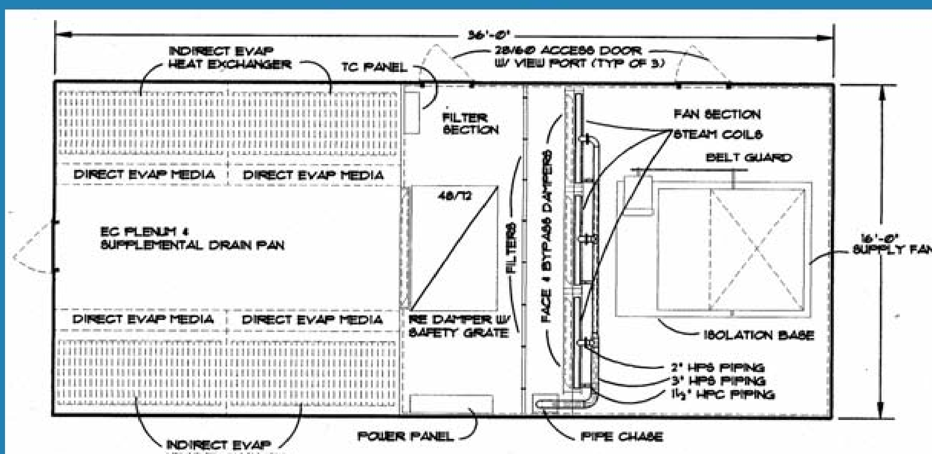
Evaporative Cooling:
Indirect/Direct Case Study

EQUIPMENT SCHEDULE

Mark	Manu-facturer	Supply Cfm	E.A.T (O.S.A) (°FDB)	E.A.T (O.S.A) (°FWB)	L.A.T. Indirect (°FDB)	L.A.T. Indirect (°FWB)	L.A.T. Direct (°FDB)	Efficiency (Indirect) (%)	Efficiency (Direct) (%)
AHU-1		62,000	91.0	75.0	78.0	71.5	72.3	80	88
AHU-2		62,000	91.0	75.0	78.0	71.5	72.3	80	88
AHU-3		62,000	91.0	75.0	78.0	71.5	72.3	80	88
AHU-4		25,000	91.0	75.0	78.0	71.5	72.2	80	90

Evaporative Cooling:
Indirect/Direct Case Study

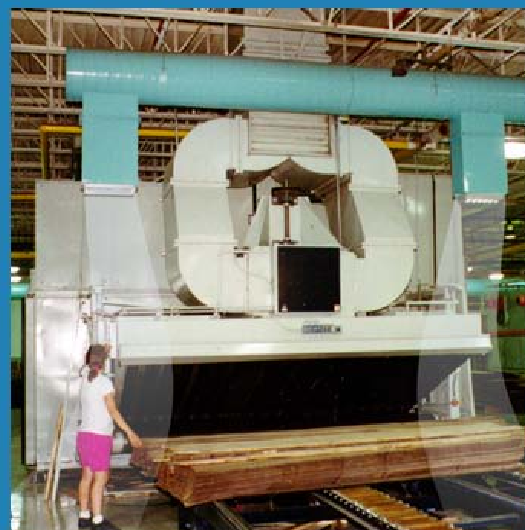
62,000 CFM Make Up Air Handling Unit



Evaporative Cooling:
Indirect/Direct Case Study

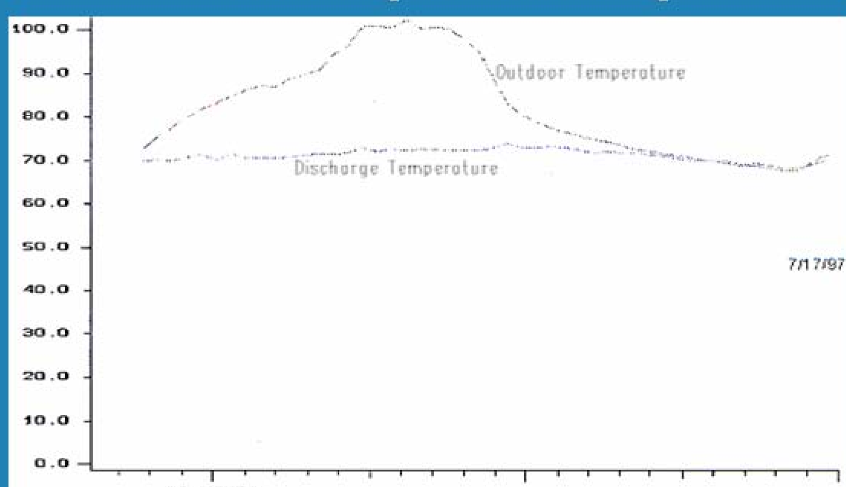
SPOT COOLING

* Adjustable Diffusers
* High Air Movement
* Establishes Cool Zone



Evaporative Cooling:
Indirect/Direct Case Study

Field Temperature Recording



Evaporative Cooling:
Indirect With Typical Rooftop Unit

- Industrial facility with high outside air requirements
  - Standard rooftop mechanical units
  - Indirect evaporative precoolers
  - DX tonnage reduced by 50%
  - Heat recovery in winter operation

Evaporative Cooling:
Indirect With Chiller & Heat Recovery

- An Indirect evaporative pre-cooler can be used to reduce the size of a new chilled water system, or can be used to reduce the outside air load on an existing system.
- When used for energy (heat) recovery in winter operations, that same indirect unit can pre-heat the outside air.
  - In certain parts of the country, the energy savings from heat recovery may be even greater than those from evaporative cooling

Evaporative Cooling:
Indirect With Chiller & Heat Recovery

IDEC COOLING PERFORMANCE (24-7 operating hours)
(ADA SYSTEMS - 955 North Lively Blvd, Wood Dale, IL 60191 / Ph: 630-238-1516)

LOCATION	MILWAUKEE	
EER SEASONAL AVERAGE	47.25	
SUPPLY AIR TEMP	55 F	
EXHAUST	75 F / 50% RH	
TOTAL HOURS OPERATION (24/7)	3180	
IDEC SIZE	450	Linear Ft
IDEC PRIMARY and SECONDARY CFM	500,000	Each
IDEC ENERGY DRAW (kW/hr) - ON	137,200	450 ft module
IDEC ENERGY DRAW (watts/hr) - OFF	70,000	450 ft module
IDEC EQUIPMENT COST	$ 2.00	per CFM
IDEC EQUIPMENT COST (per ton uninstalled)	$ 765	per ton cooling
CHILLED WATER COSTS (per ton uninstalled)	$ 425	per ton cooling
Premium for IDEC over chilled water	$440,000	Job Total
IDEC TONS	1,307	
IDEC Efficiency	80%	
Kw/hr Cost	$ 0.06	
Water Cost (per 1000 gallons)	$ 2.00	
IDEC YEARLY OPERATING COST - TOTAL (24/7)	$ 26,348	
EQUIVALENT MECHANICAL YEARLY COST	$124,494	
YEARLY SAVINGS using IDEC	$ 98,100	

PRIMARY Air Entering DB (F)	PRIMARY Air Entering WB (F)	PRIMARY Air Entering H Btu/lb	SECONDARY Air entering DB (F)	SECONDARY Air entering WB (F)	SECONDARY Air entering H Btu/lb	PRIMARY Air leaving DB (F)	PRIMARY Air leaving WB (F)	PRIMARY Air leaving H Btu/lb	IDEC Btu/Lb Drop	IDEC Out Btu/hr Drop	IDEC Input Watts/Hr	EER Btu Per Watt	HRS Total Yearly BIN	ENERGY Output for each BIN	ENERGY BIN% of Total Output	EER Contribution /BIN	ENERGY Input for Each /BIN	COST Energy Input IDEC	GALS Water Consumption	COST Water Consumption	OPERATING Cost TOTAL
97	76	39.38	75	63	28.49	69.8	68.0	32.41	7.0	1.6E+07	137,200	114.3	6	9.4E+07	1%	0.7	8.2E+05	$ 49	500	$ 1	$ 50
92	74	37.50	75	63	28.49	68.8	67.5	32.01	5.5	1.2E+07	137,200	90.0	58	7.2E+08	5%	4.4	8.0E+06	$ 477	4,500	$ 9	$ 486
87	72	35.71	75	63	28.49	67.8	66.5	31.21	4.5	1.0E+07	137,200	73.8	165	1.7E+09	11%	8.4	2.3E+07	$ 1,358	10,500	$ 21	$ 1,379
82	70	33.99	75	63	28.49	66.8	65.0	30.05	3.9	8.9E+06	137,200	64.6	324	2.9E+09	20%	12.7	4.4E+07	$ 2,667	16,000	$ 32	$ 2,699
77	67	31.54	75	63	28.49	65.8	63.2	28.70	2.8	6.4E+06	137,200	46.6	487	3.1E+09	21%	9.9	6.7E+07	$ 4,009	18,000	$ 36	$ 4,045
72	64	29.25	75	63	28.49	64.8	61.8	27.69	1.6	3.5E+06	137,200	25.6	681	2.4E+09	16%	4.2	9.3E+07	$ 5,606	16,000	$ 32	$ 5,638
67	61	27.11	67	61	28.49	62.2	59.2	25.90	1.2	2.7E+06	137,200	19.8	759	2.1E+09	14%	2.8	1.0E+08	$ 6,248	11,500	$ 23	$ 6,271
62	57	24.44	62	57	28.49	58.0	55.2	23.33	1.1	2.5E+06	137,200	18.2	700	1.7E+09	12%	2.2	9.6E+07	$ 5,762	8,100	$ 16	$ 5,779
													3180	1.5E+10	100%	45.2	4.4E+08	$ 26,178	85,100	$ 170	$ 26,348

Evaporative Cooling:
Indirect With Chiller & Heat Recovery

IDEC HEATING PERFORMANCE (24/7 operating hours)
(ADA SYSTEMS - 425 North Gary Ave, Carol Stream, IL 60188 / Ph: 630-871-2500)

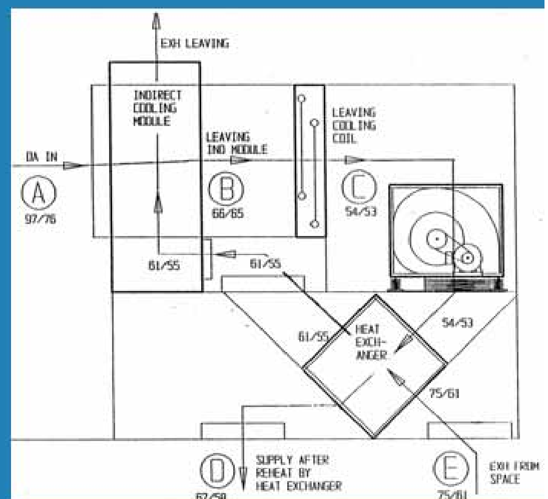
LOCATION	MILWAUKEE
TOTAL HOURS OPERATION (24 hour /7 day)	5568
IDEC SIZE	450 Ln Ft
IDEC PRIMARY and SECONDARY CFM	500,000 Each
IDEC ENERGY DRAW (Kw/hr) - pumps off	70.0
IDEC EQUIPMENT COST (per CFM)	$ 2.00
IDEC EFF (dry)	65%
Kw/hr Cost	$ 0.06
NatGas (per Therm)	$ 0.40
Assumed Furnace Efficiency	80%
YEARLY HEATING SEASON SAVINGS	$354,300

SUMMARY	
Yearly Heating Savings	$354,300
Yearly Cooling Savings	$ 98,100
TOTAL Yearly Savings	$452,400
IDEC Premium	$440,000
PAYBACK - Years	0.97

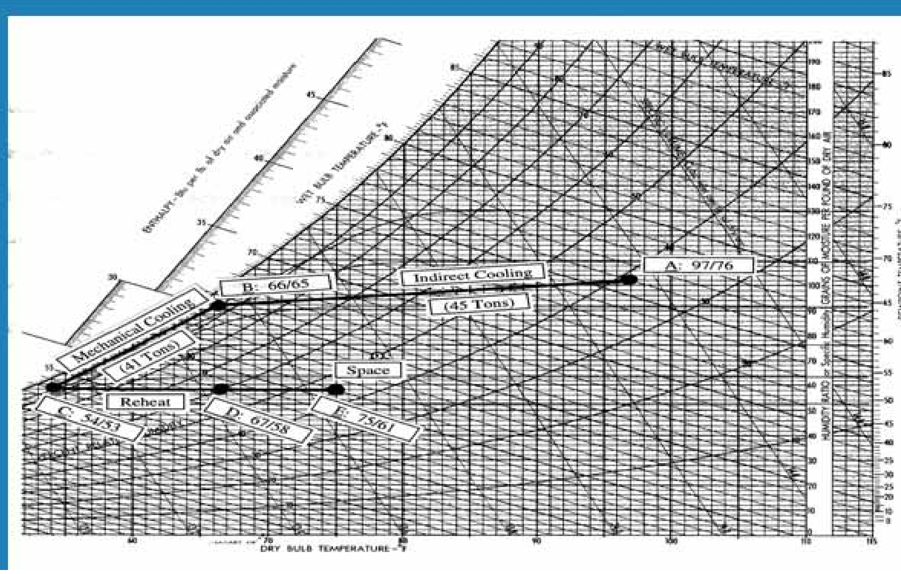
SUPPLY AIR ENTERING (F)	EXHAUST AIR ENTERING (F)	HOURS PER YEAR (Hrs)	SUPPLY AIR LEAVING (F)	EXHAUST AIR LEAVING (F)	BTU/HR RECOVERED (Btu/hr)	BTU/BIN RECOVERED (Btu/bin)	THERMS PER BIN /Furn Eff	SAVINGS PER BIN	PARASIDICAL LOSS (Kw)	PARASIDICAL LOSS ($)	NET SAVINGS ($)
57	75	604	69	63	6.3E+06	3.83E+09	47,922	$ 19,169	42,280	$ 2,537	$ 16,632
52	75	581	67	60	8.1E+06	4.71E+09	58,902	$ 23,561	40,670	$ 2,440	$ 21,120
47	75	565	65	57	9.9E+06	5.58E+09	69,732	$ 27,893	39,550	$ 2,373	$ 25,520
42	75	572	63	54	1.2E+07	6.66E+09	83,202	$ 33,281	40,040	$ 2,402	$ 30,878
37	75	725	62	50	1.3E+07	9.71E+09	121,435	$ 48,574	50,750	$ 3,045	$ 45,529
32	75	869	60	47	1.5E+07	1.32E+10	164,707	$ 65,883	60,830	$ 3,650	$ 62,233
27	75	589	58	44	1.7E+07	9.97E+09	124,618	$ 49,847	41,230	$ 2,474	$ 47,373
22	75	371	56	41	1.9E+07	6.93E+09	86,671	$ 34,668	25,970	$ 1,558	$ 33,110
17	75	231	55	37	2.0E+07	4.72E+09	59,056	$ 23,622	16,170	$ 970	$ 22,652
12	75	164	53	34	2.2E+07	3.64E+09	45,542	$ 18,217	11,480	$ 689	$ 17,528
7	75	115	48	34	2.2E+07	2.56E+09	31,974	$ 12,789	8,050	$ 483	$ 12,306
2	75	89	43	34	2.2E+07	1.98E+09	24,745	$ 9,898	6,230	$ 374	$ 9,524
-3	75	53	38	34	2.2E+07	1.18E+09	14,736	$ 5,894	3,710	$ 223	$ 5,672
-8	75	27	33	34	2.2E+07	6.01E+08	7,507	$ 3,003	1,890	$ 113	$ 2,889
-13	75	11	28	34	2.2E+07	2.45E+08	3,058	$ 1,223	770	$ 46	$ 1,177
-17	75	2	24	34	2.2E+07	4.45E+07	445	$ 178	140	$ 8	$ 170

Evaporative Cooling:
Indirect/Mechanical (Low Energy Reheat)

- Facilities with high OSA needs often require expensive reheat
- Components of a low energy reheat system:
  - Indirect evaporative pre-cooler
  - Mechanical cooling coil
  - Secondary heat exchanger



Evaporative Cooling:
Indirect/Mechanical (Low Energy Reheat)

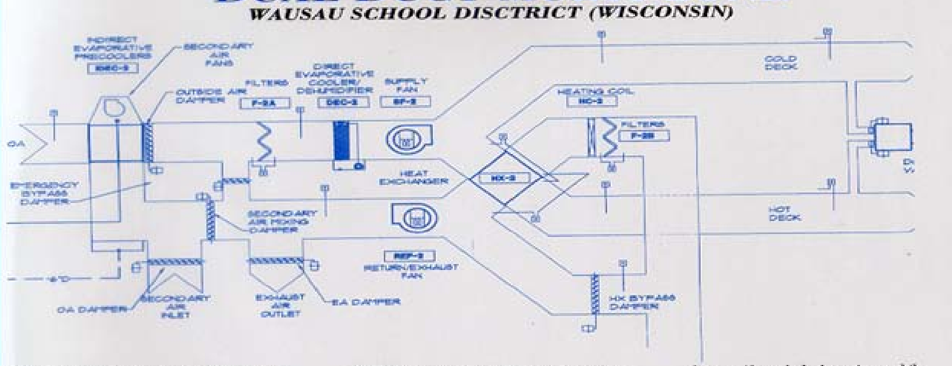


Evaporative Cooling:
Hybrid (Multi-Functional) System

- Wausau West High School, Wausau, WI
- Problems they were facing:
  - Expensive retrofit of existing chiller plant
  - Severe indoor air quality
  - Non-compliance with Standard 62

Evaporative Cooling:
Hybrid (Multi-Functional) System

DUAL DUCT MULTI-ZONE
WAUSAU SCHOOL DISCTRICT (WISCONSIN)



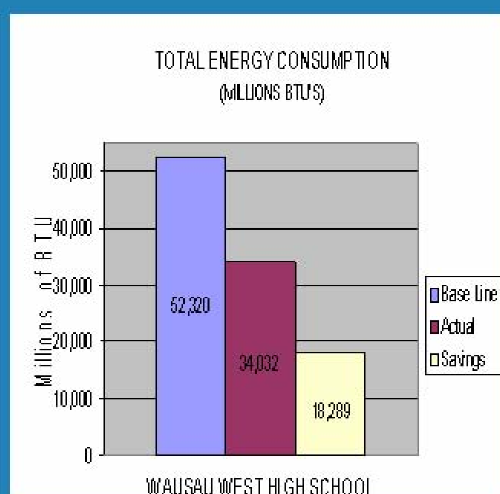
1) Energy Efficiency is greatly enhanced through the use of evaporative coolers and air-to-air heat exchangers.
2) IAQ is improved by the use of large quantities of outdoor air and through the washing of the supply air inside the DEC unit which extracts condensible gases responsible for sick building syndrome and which cannot be removed by conventional filters.
3) Hydronic perimeter heating is used to prevent building heat loss.
4) Dual-Duct VAV boxes are used to provide cooling to the individual building zones.
5) Very inexpensive cooling is provided by the IDEC(idec-2) unit which provides first stage cool, and the DEC(dec-2) unit which provides second stage cooling.
6) Auxilliary cooling can be added in the future - if needed - by using a chil cool supply water (through a secor heat exchanger loop) before enteri DEC unit.
7) The HX (hx-2) heat exchanger free heating for the hot deck. In h weather, the HX is bypassed.
8) The heat exchanger located wit IDEC recovers heat and cooling fr building exhaust.

Evaporative Cooling:
Hybrid (Multi-Functional) System

- Wausau West High School
- Area: 275,000 S/F
- System Type: Regenerative Double Duct™
- Primary Heating Plant Reduction: 60%
- Primary Cooling Plant Reduction: 92%
- Gross Energy Use Reductions:
  - Natural Gas: 38%
  - Electricity (kWh): 27.8%
  - Electrical Demand: 25%
- Gross Energy Cost Reductions: 29.3%

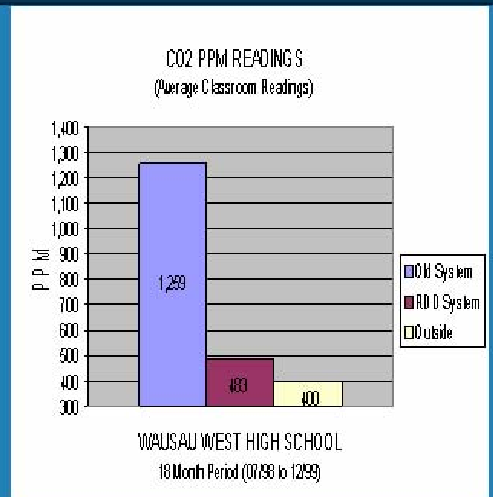
Evaporative Cooling:
Hybrid (Multi-Functional) System

- "Base Line" energy consumption based on the former HVAC system that utilized **minimum outside air** and recirculated a majority of existing building air
- "Actual" energy consumption based on the new **100% outside air** HVAC system



Evaporative Cooling:
Hybrid (Multi-Functional) System

- ASHRAE Standard 62.1-2001 uses an indoor to outdoor differential concentration not greater than 700 ppm of CO_2 as an indicator of acceptable indoor air quality



Evaporative Cooling:
Hybrid (Multi-Functional) System

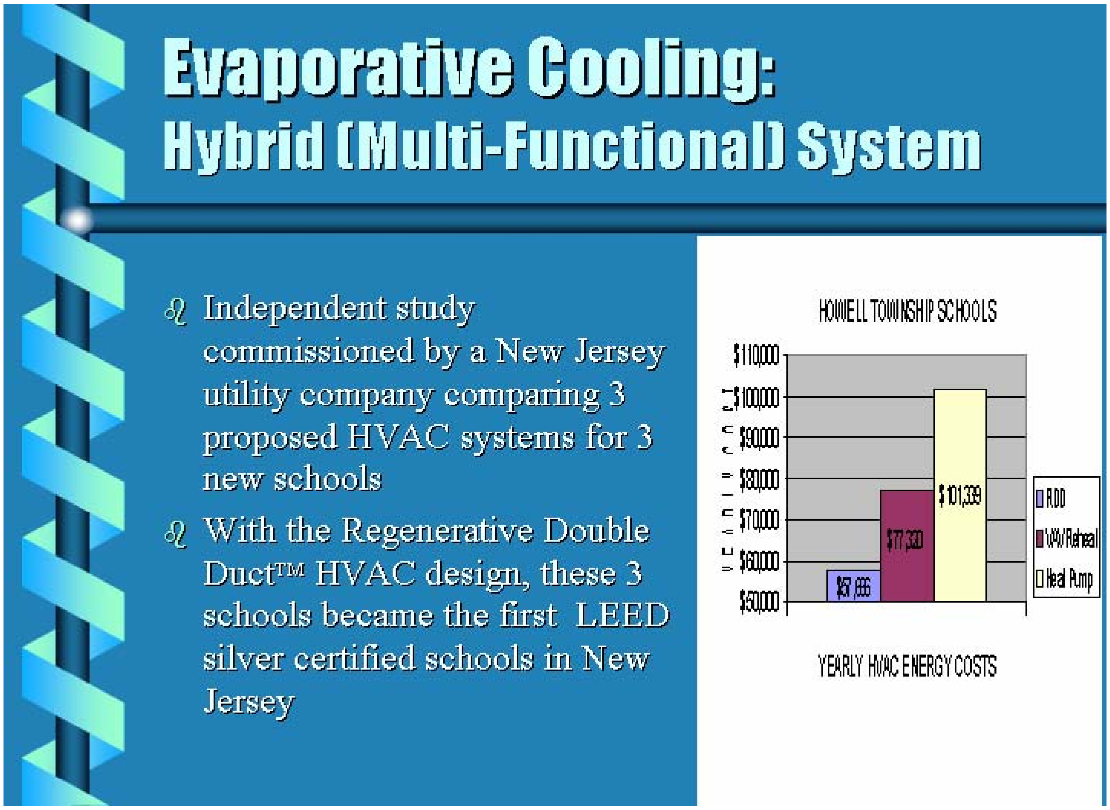
- Advantages to the Hybrid system:
  - Lower first cost (especially for new construction)
  - Reduced energy usage (up to 70%)
  - Improved indoor air quality
    - Larger amounts of outdoor air
    - Direct section acts as an air scrubber

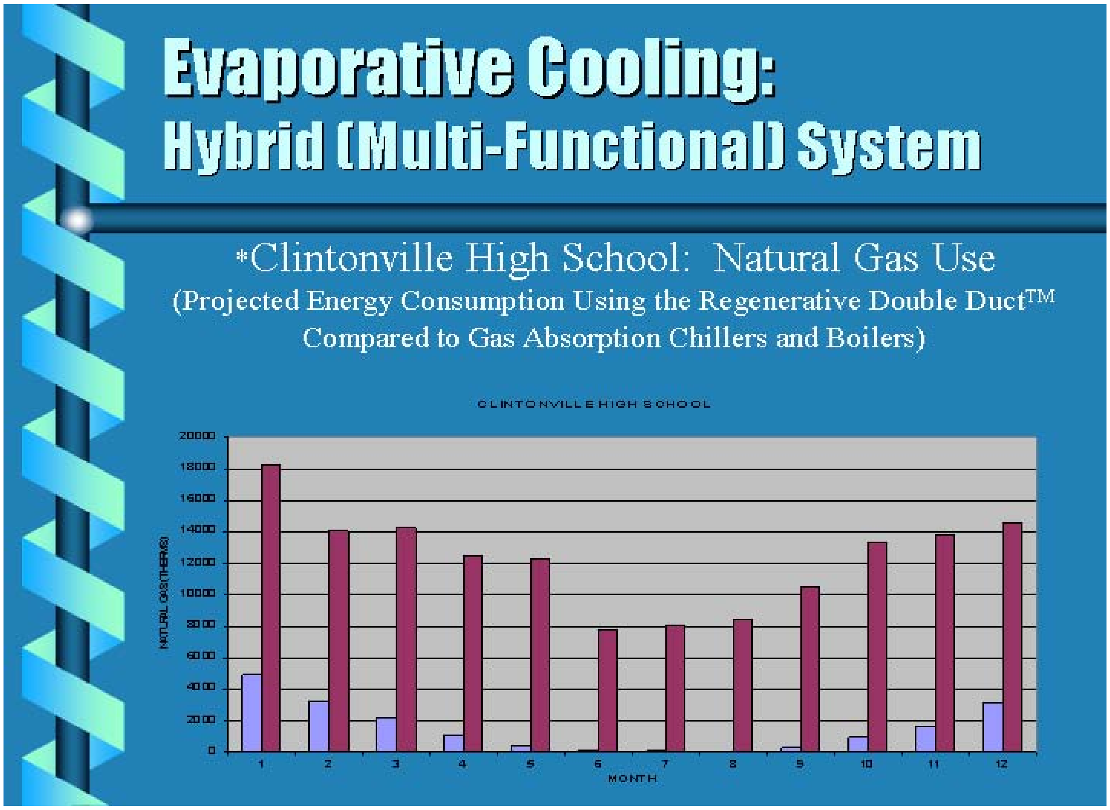

Evaporative Cooling:
Hybrid (Multi-Functional) System

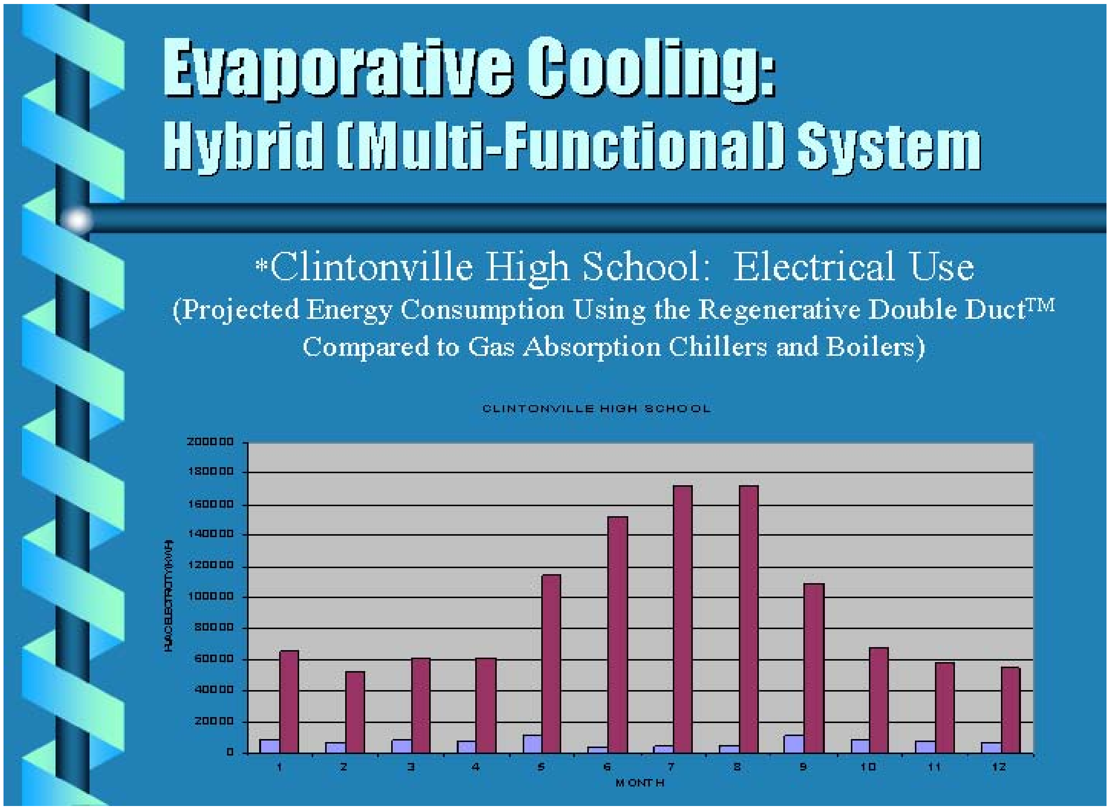

Evaporative Cooling:
Hybrid (Multi-Functional) System

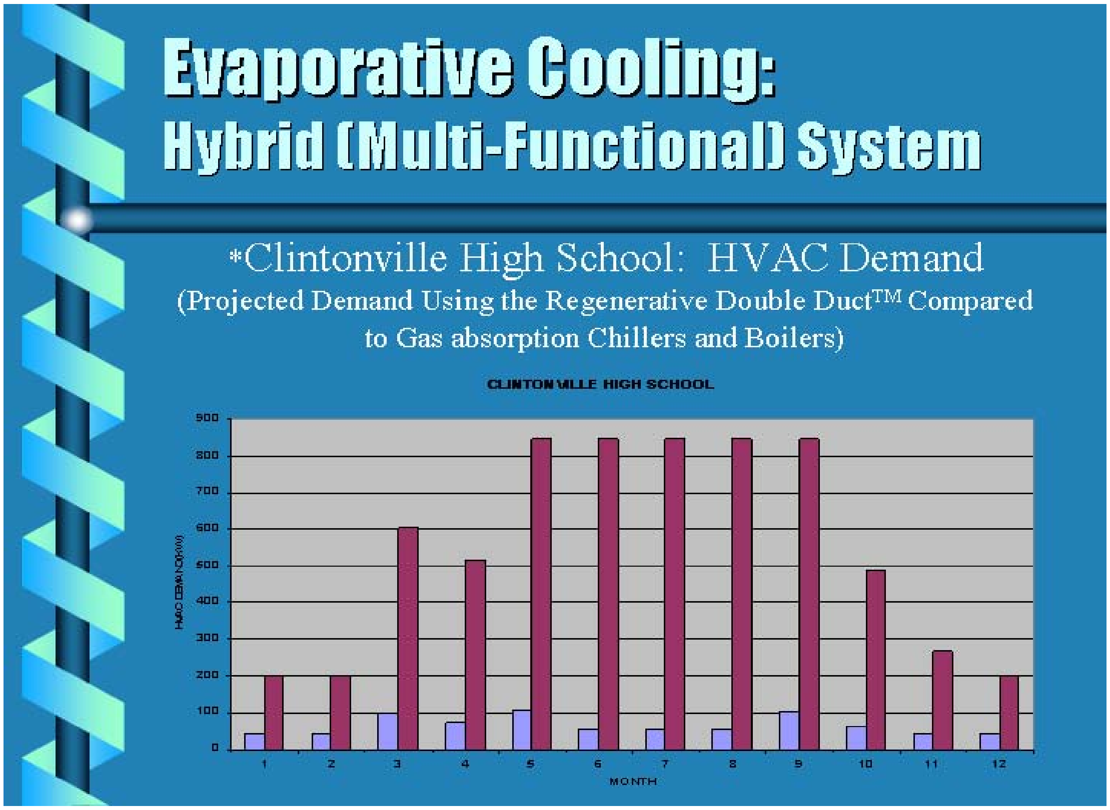

Evaporative Cooling:
Hybrid (Multi-Functional) System

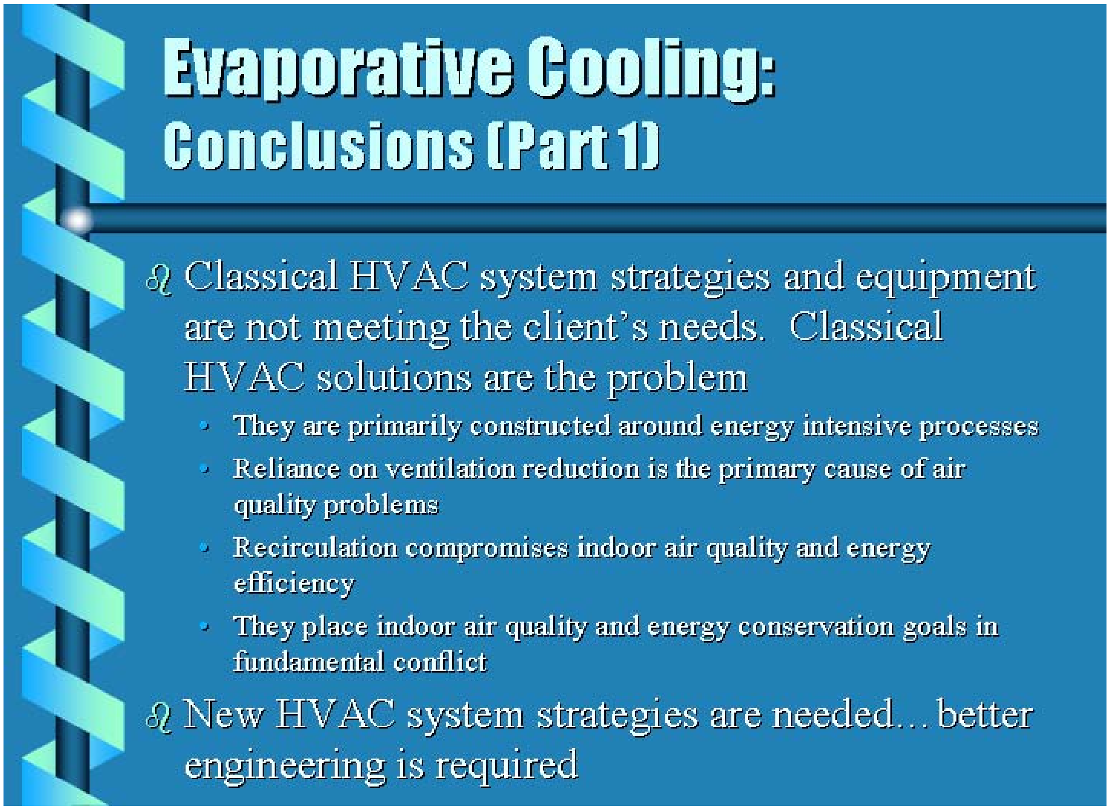

Evaporative Cooling:
Hybrid (Multi-Functional) System
THERMIFIC

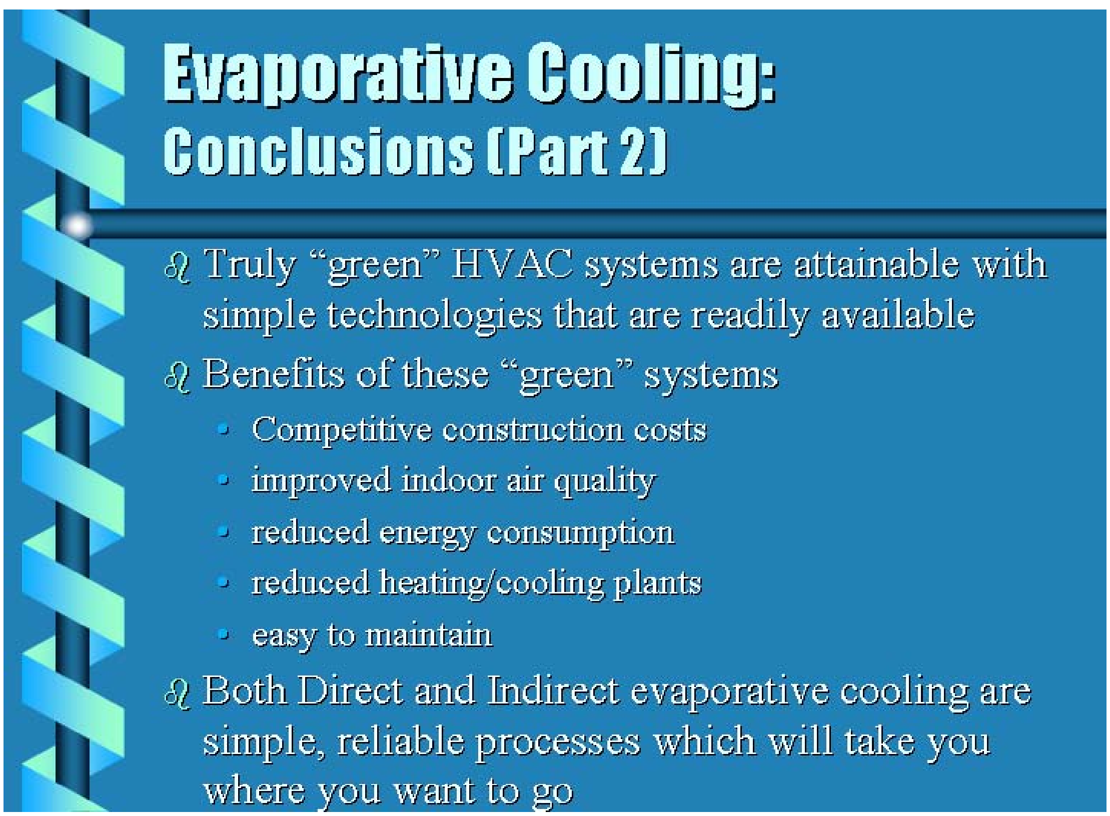

Evaporative Cooling:
Hybrid (Multi-Functional) System
Independent study commissioned by a New Jersey utility company comparing 3 proposed HVAC systems for 3 new schools
With the Regenerative Double Duct™ HVAC design, these 3 schools became the first LEED silver certified schools in New Jersey
HOWELL TOWNSHIP SCHOOLS
$110,000
$100,000
$90,000
$80,000
$70,000
$60,000
$50,000
$57,666
$77,320
$101,339
RDD
VAV/Reheat
Heat Pump
YEARLY HVAC ENERGY COSTS


Evaporative Cooling:
Hybrid (Multi-Functional) System
*Clintonville High School: Natural Gas Use
(Projected Energy Consumption Using the Regenerative Double Duct™ Compared to Gas Absorption Chillers and Boilers)
CLINTONVILLE HIGH SCHOOL
NATURAL GAS (THERMS)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1
2
3
4
5
6
7
8
9
10
11
12
MONTH


Evaporative Cooling:
Hybrid (Multi-Functional) System
*Clintonville High School: Electrical Use
(Projected Energy Consumption Using the Regenerative Double Duct™ Compared to Gas Absorption Chillers and Boilers)
CLINTONVILLE HIGH SCHOOL
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1 2 3 4 5 6 7 8 9 10 11 12
MONTH


Evaporative Cooling:
Hybrid (Multi-Functional) System
*Clintonville High School: HVAC Demand
(Projected Demand Using the Regenerative Double Duct™ Compared to Gas absorption Chillers and Boilers)
CLINTONVILLE HIGH SCHOOL
900
800
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12
MONTH


Evaporative Cooling:
Conclusions (Part 1)
Classical HVAC system strategies and equipment are not meeting the client's needs. Classical HVAC solutions are the problem
They are primarily constructed around energy intensive processes
Reliance on ventilation reduction is the primary cause of air quality problems
Recirculation compromises indoor air quality and energy efficiency
They place indoor air quality and energy conservation goals in fundamental conflict
New HVAC system strategies are needed… better engineering is required


Evaporative Cooling:
Conclusions (Part 2)
Truly "green" HVAC systems are attainable with simple technologies that are readily available
Benefits of these "green" systems
Competitive construction costs
improved indoor air quality
reduced energy consumption
reduced heating/cooling plants
easy to maintain
Both Direct and Indirect evaporative cooling are simple, reliable processes which will take you where you want to go

Geothermal opportunities for ESPCs

Presenter: Mr. Mike Lemmon. LSB Industries.

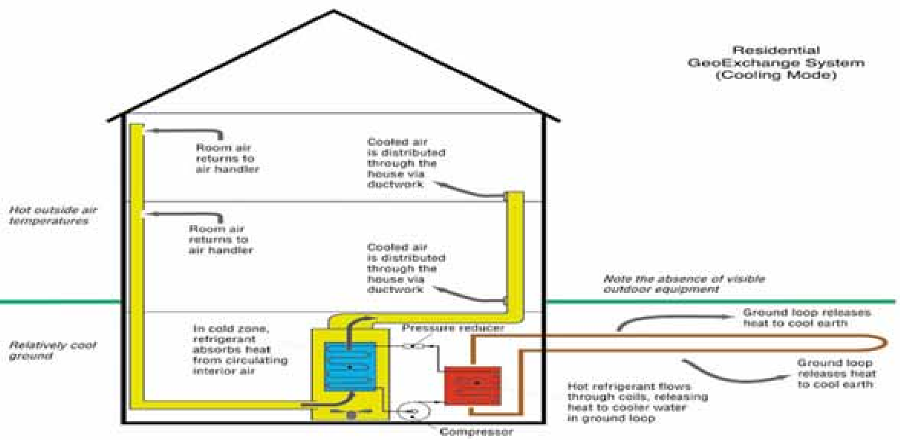
Introduction

- LSB Industries is a provider of hydronic equipment and solutions
- IEC fan coils, Climatemaster heat Pumps, ClimaCool modular chillers, and ClimateCraft air handling units in federal buildings around the world
- We are **not** an Energy Service Company but work with Energy Service Companies to provide HVAC solutions through our Climate Control Group

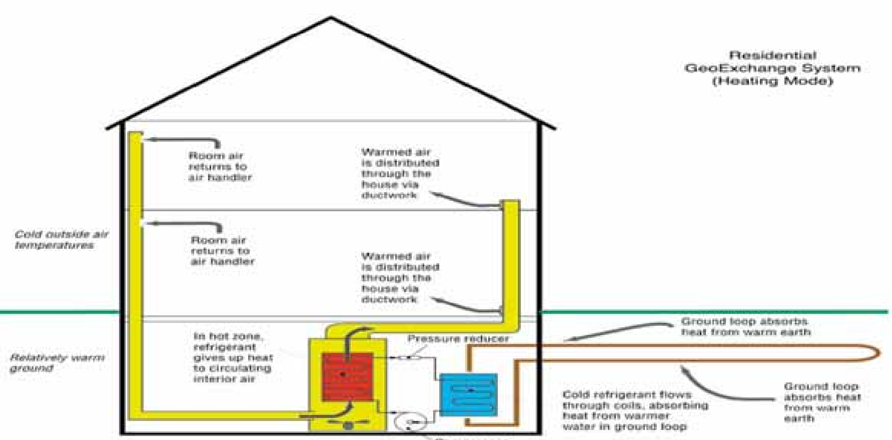
Objectives : Opportunities for Geothermal

- The Technology
- Side by Side Comparison of Geothermal and a Central Chilled Water VAV System
- Economic Hurdles for Geothermal
- Hybrid Energy Saving Solutions

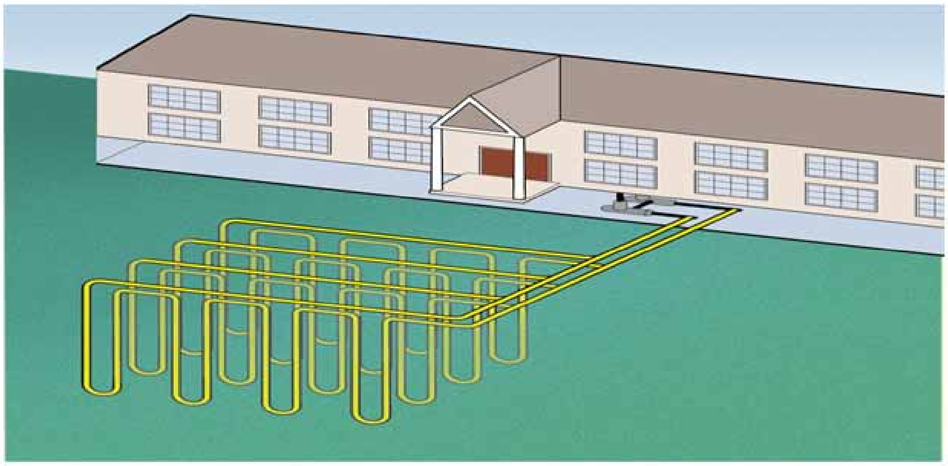
Geothermal in the Summer



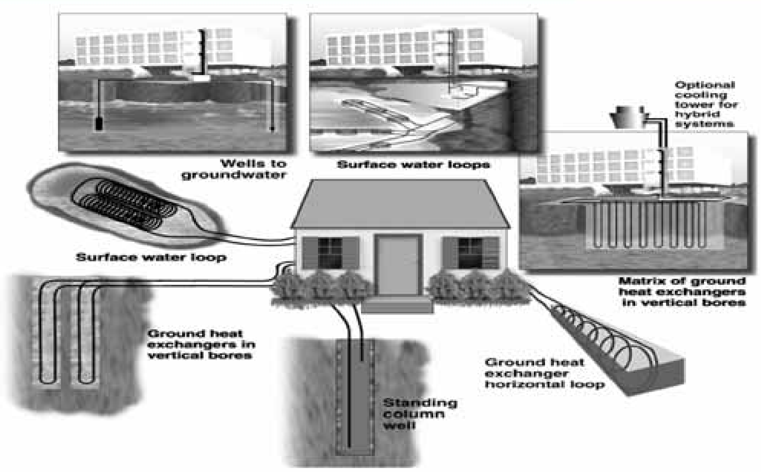
Geothermal in the Winter



Commercial Vertical Loop Application



Other Ways to Reject and Recover Heat…



Issues That Geothermal Addresses

- Energy Mandates
- Mechanical Room Space constraints
- Changing Building Occupancy Patterns
- Existing Building space and design constraints
- Year Round Conditioning of buildings and Zones
- Terminal Comfort and Control
- Indoor Air Quality – Humidity Control
- Comfort, Morale, Building Aesthetics

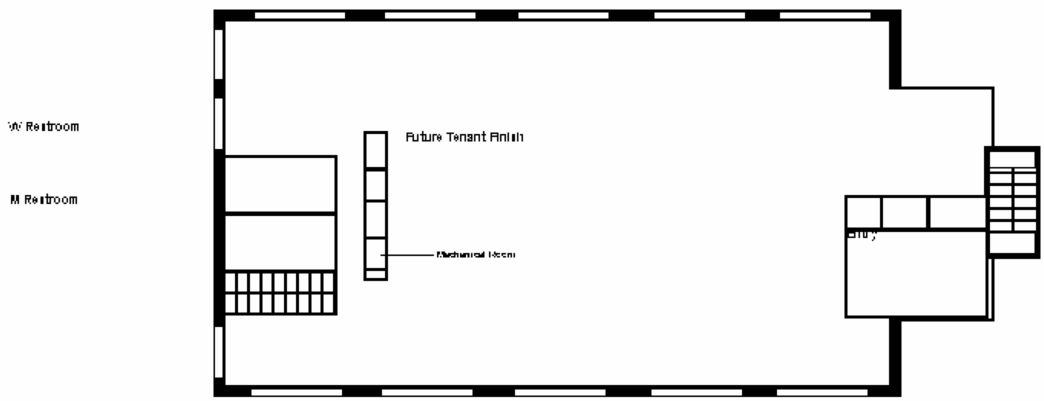
Comparison of Geothermal with a Conventional System

Garrett Office Buildings
Edmond, Oklahoma

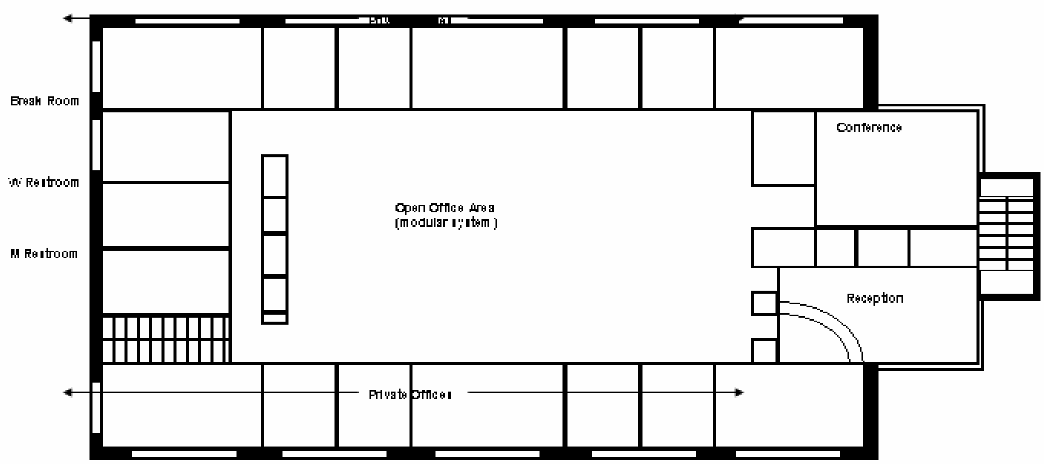
Geothermal Building
20,000 Sq. Ft.

VAV Building
15,000 Sq. Ft.

Geothermal Building
Floor 1 Plan



Geothermal Building
Floor 2 Plan

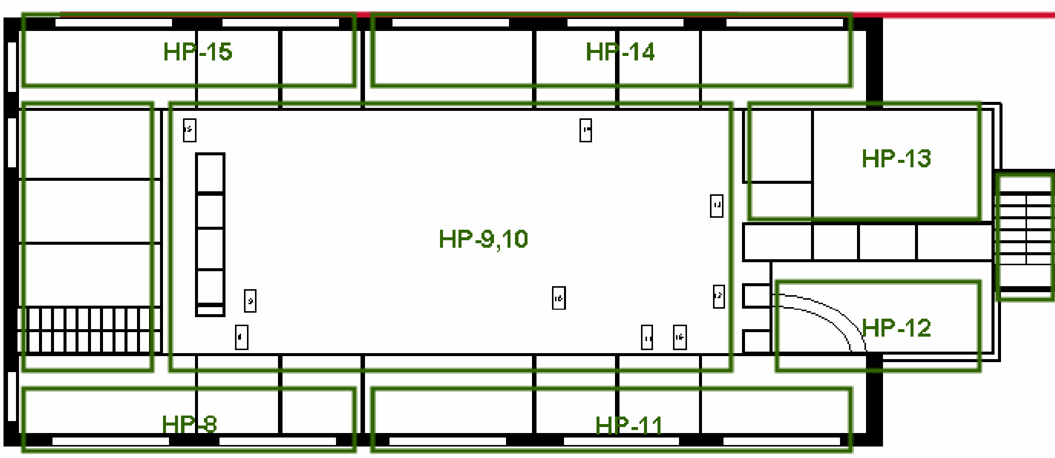


Floor 2 Conference

Floor 2 Private Office

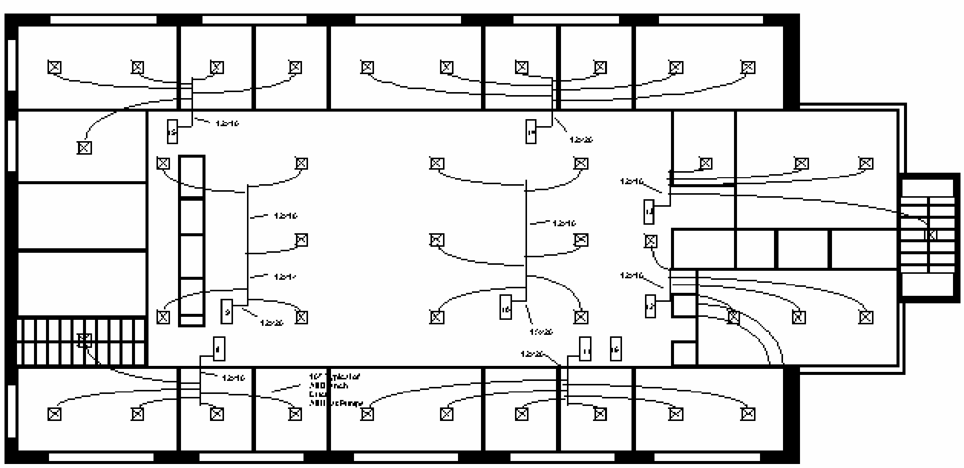
Floor 2 Open Office Space

Geothermal Building
Floor 2 Heat Pump Zoning

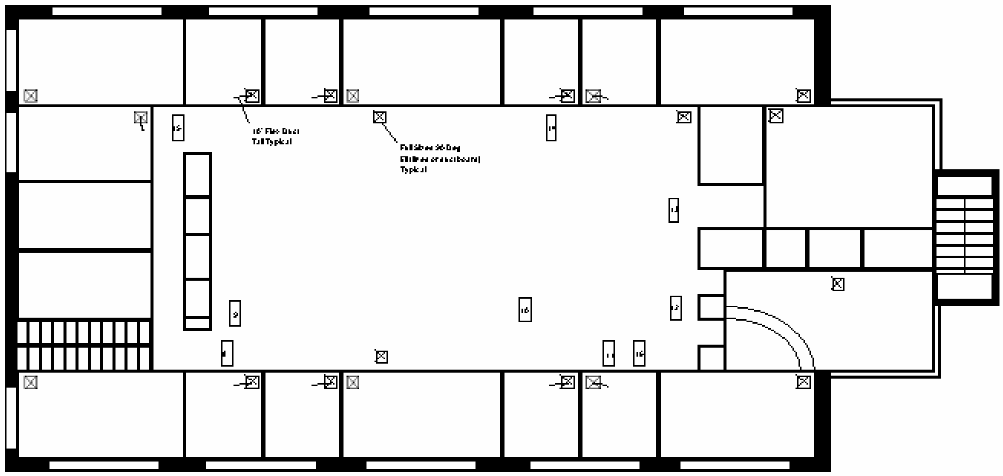


Typical Heat Pump

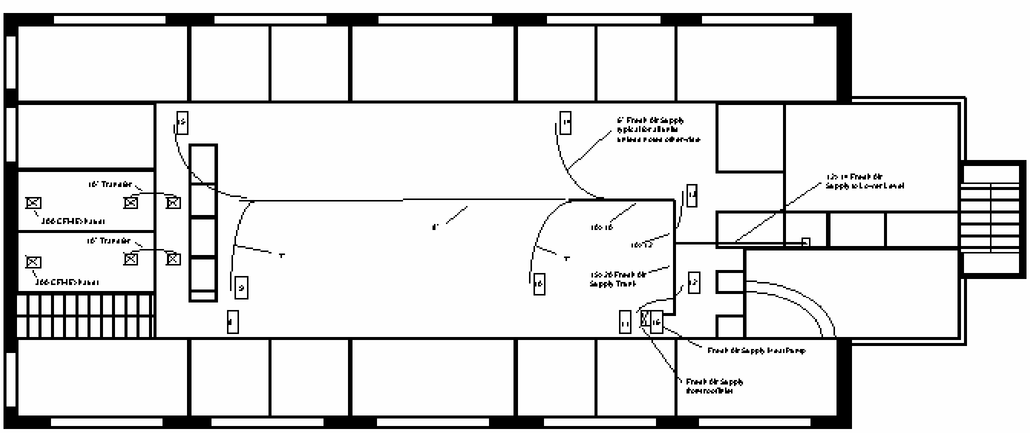
Geothermal Building Floor 2 Heat Pump Supply Ducts



Geothermal Building
Floor 2 Heat Pump Return Ducts

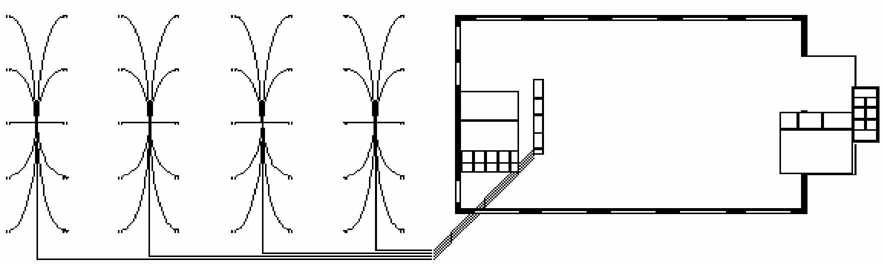


Geothermal Building
Floor 2 Ventilation Ducts

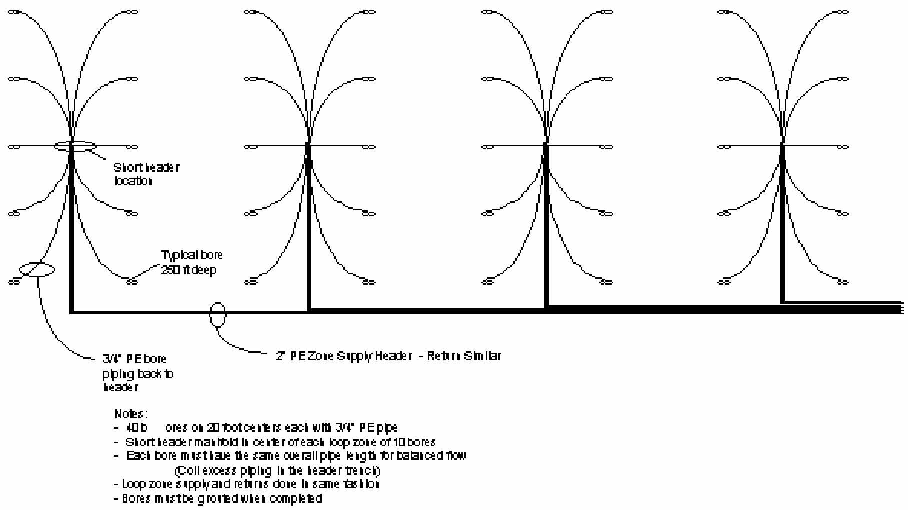


Loop Field Overview

Geothermal Building Loop Field Site Plan

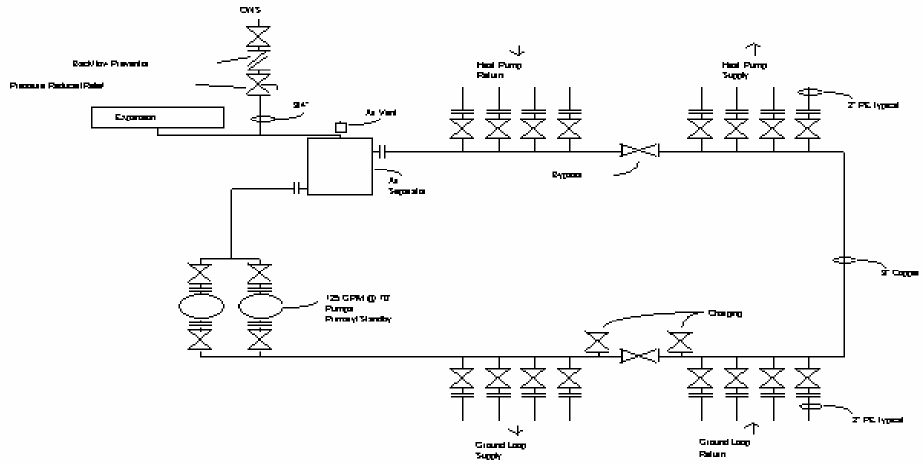


Loop Field Details

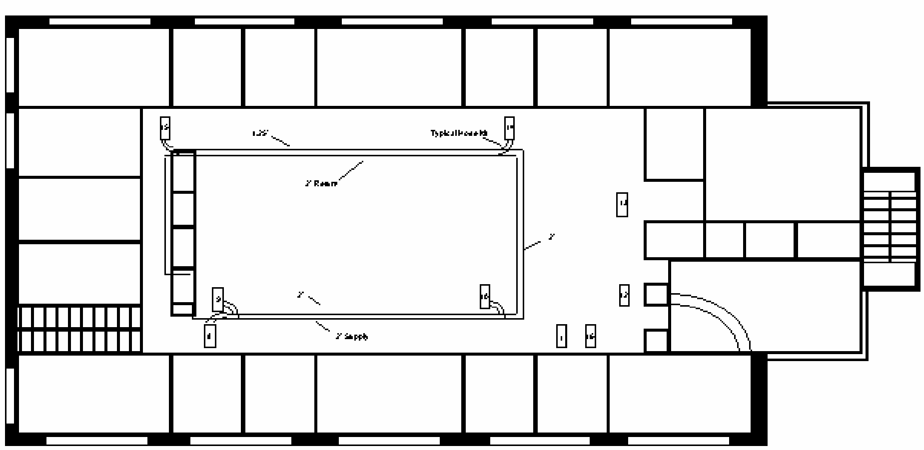


Geothermal Mechanical Room

Geothermal Mechanical Room



Geothermal Building Floor 2 Heat Pump Piping Zone 3



Floor 1 Heat Pump Piping

Floor 1 Heat Pump Piping

Garrett Office Buildings
Highway View

Geothermal Building
Roof View

VAV Building
Roof View

VAV Building
Central Air Handler

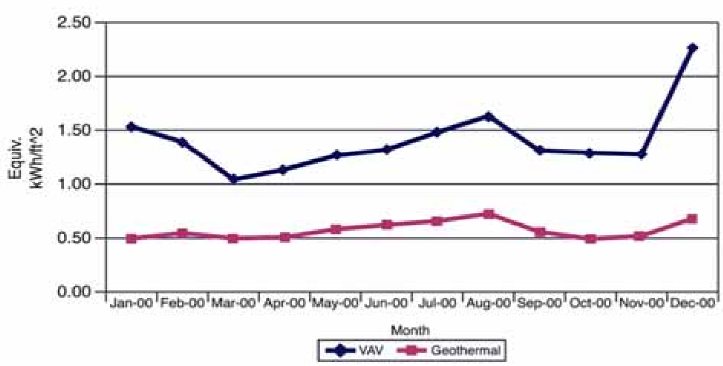
VAV Building
Air-Cooled Condensing Unit

VAV Building
Boiler Room

Garrett Office Buildings
2000 Energy Consumption

Month	VAV 15,000 ft^2		Geothermal 20,000 ft^2	
	Gas Mcf	Elec kWh	Gas Mcf	Elec kWh
Jan-00	36.2	12,400	0.0	9,920
Feb-00	21.0	14,720	0.0	10,880
Mar-00	6.9	13,600	0.0	9,960
Apr-00	4.3	15,760	0.0	10,120
May-00	3.5	17,920	0.0	11,600
Jun-00	4.2	18,560	0.0	12,400
Jul-00	3.2	21,280	0.0	13,120
Aug-00	3.2	23,520	0.0	14,480
Sep-00	3.2	18,720	0.0	11,120
Oct-00	11.2	16,080	0.0	9,840
Nov-00	21.9	12,720	0.0	10,360
Dec-00	69.4	13,600	0.0	13,600
Total	**188.2**	**198,880**	**0.0**	**137,400**
$ Cost	**$ 1,882**	**$ 17,899**	**$**	**$ 10,992**
$/ft^2	**1.32**		**0.55**	

Garrett Office Buildings
2000 Energy Consumption Profile



Garrett Office Buildings Installation Costs

- Geothermal System circa 1998
  - Complete exterior loop, mechanical room, interior PE piping, flushing and unit startup, heat pumps, duct work, exhausts, MUA system, time clock-based controls
  - $128,700 ($2,574 per ton)
- VAV System circa 1987
  - air-cooled condenser, VAV air handler, boiler, VAV boxes with reheat coils, economizer, electronic controls
  - $100,000 ($2000 per ton)
  - costs per building owner do not include structural or architectural

Economic Hurdles for Geothermal

- Projects to Date – *the tests are over*
- Results – *are here!*
- Do the Savings generate enough cash flow for a self-funding ESPC?
- Is geothermal an economic win?
- Mitigating the project and performance risks – a sensible approach.

Future of Geothermal in ESPCs: *Hybrid Geothermal Systems*

- Continued Use of Close – Loop Vertical Systems
- Hybrid systems consisting of Geothermal and a peak demand shaving technologies
- Central Bore Fields with vertical heat exchangers, production/ re-injection wells
- Distributed Pumping
- Combined Heat and Power or Thermal Energy Storage or Injection well system

Geothermal with Existing Hydronic Systems

- Combined Benefits
- Benefits of Geothermal Heating / Benefits of Hydronic Heating:
  - Greater comfort than forced air
  - Energy savings over forced air
  - No air movement in heating (less dust)
  - Greater flexibility in zoning
  - Lowers heat loss

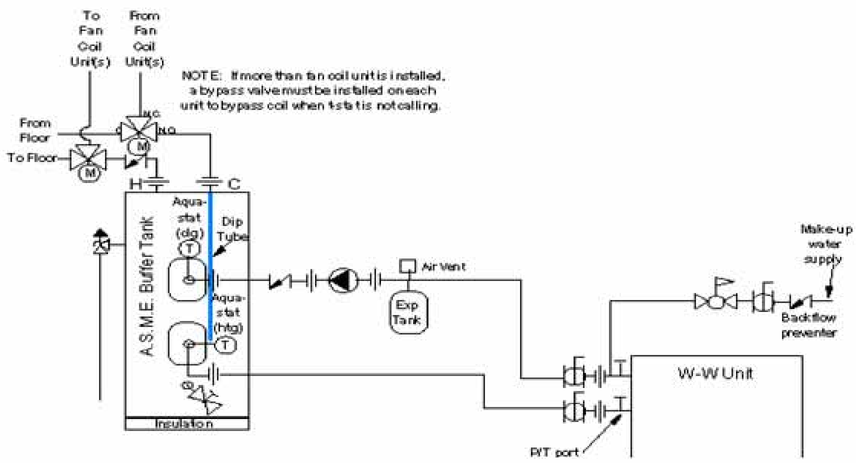
Delivery Systems - Heating

- Radiant Floor
- Baseboard radiation
- Cast iron radiators
- Fan coil units

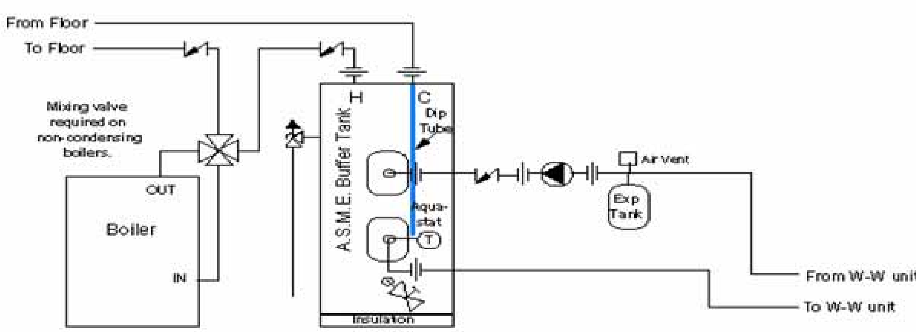
Various Configurations of Geothermal Systems

- Water-to-water unit's - heating only
- Water-to-water unit's for heating; water-to air unit's for cooling
- Water-to-water unit's for heating and cooling (with fan coil units)

Water – To – Water Geothermal with Existing Fan Coil Units

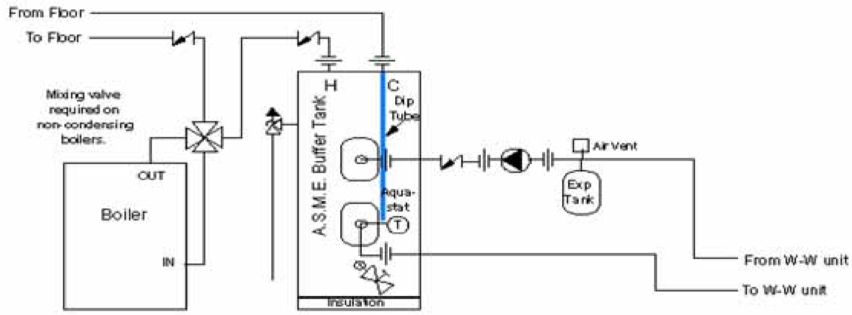


Geothermal and Boiler – Extended Capacity



*Backup boiler is for capacity, not for higher water temperatures.

Geothermal and Boiler – Extended Temperatures



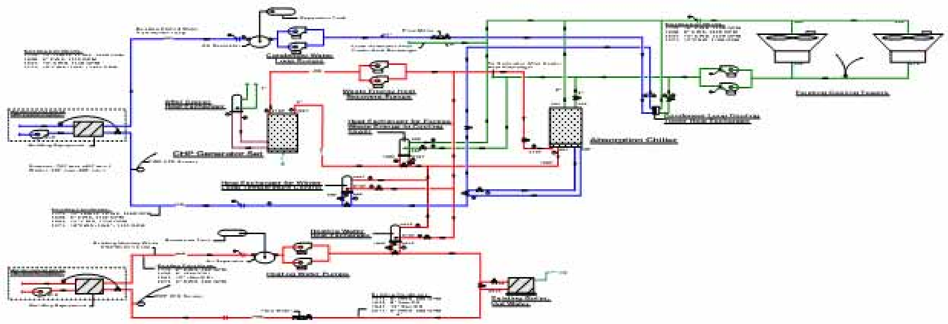
*Backup boiler is for capacity, not for higher water temperatures.

Heat Pump Technology and Combined Heat and Power:

- Combined Heat and Power
  - Reciprocating Natural Gas Engine
  - Micro-Turbine
  - Fuel Cells

- Heat Pumps can be the key to providing enough thermal load to meet the economics hurdles of Combined Heat and Power.

Hybrid Heat Pump / Combined Heat and Power



Thank you for your time and participation!

Case Histories Utilizing Total Energy Recovery for Preconditioning Outside Air

Presenter: Mr. Douglas Haas. SEMCO Incorporated

Key HVAC Market Drivers

- ASHRAE Standard 62-2001 *Ventilation for Acceptable Indoor Air Quality*.
- ASHRAE Standard 90.1 *Energy Efficient Design of New Buildings Except Low Rise Residential Buildings*.
- Energy Policy Act of 1992 (EPAct) which codifies ASHRAE 90.1 into law.
- International Building Code - Establishes specific cfm requirements for specific applications.

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ASHRAE 62-2001 IAQ Standard

- Purpose: To provide adequate dilution ventilation to occupied spaces and insure a healthy indoor environment. The outdoor air must be provided to the space continuously when occupied.
- Impact: Increases the amount of outdoor supplied to most facilities by a factor of four (20 vs. 5 cfm/person). Recommends 30-60% space RH. Major impact on the performance of conventional HVAC systems.
- Link to Energy Code 90.1
- Trend: New body of research is supporting the need for increasing the ventilation rates even further to 25 or 30 cfm/person (ie: OSHA, U.S. Airforce, DOE Schools Investigation).

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ASHRAE 62 Presents Problems for Conventional HVAC Equipment

- Increasing outdoor air elevates latent loads during the cooling season, making humidity control far more difficult. Sensible heat ratios of .55-.65 are required, far below the .8 SHR delivered by conventional equipment.
- Since the outdoor air must be provided continuously, humidity control problems occur when the coil is cycled off since humid air is dumped directly into the space.
- During the heating cycle, cold air is dumped into the space, creates drafts and low indoor relative humidity. Risk of freezing coils on cold days.
- The energy cost associated with conventional systems with increased outdoor air can be very significant (Life Cycle Cost).

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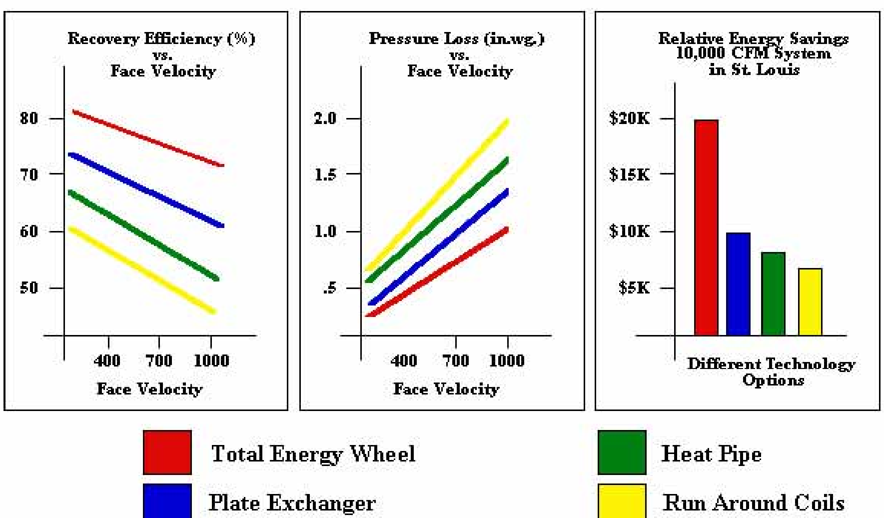
A Significant Difference in Savings: Total Recovery vs. Sensible Only



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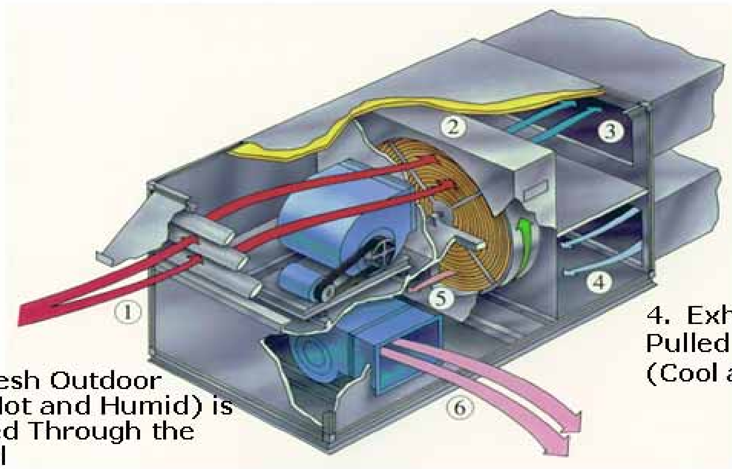
How It Works: (Cooling Season)



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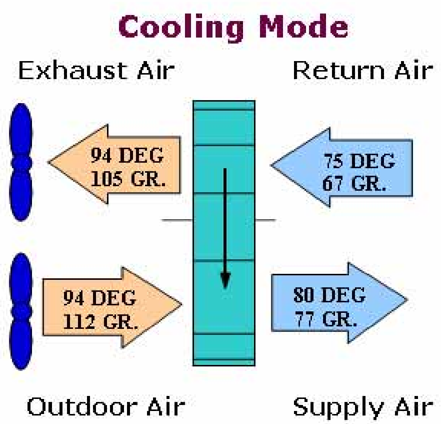
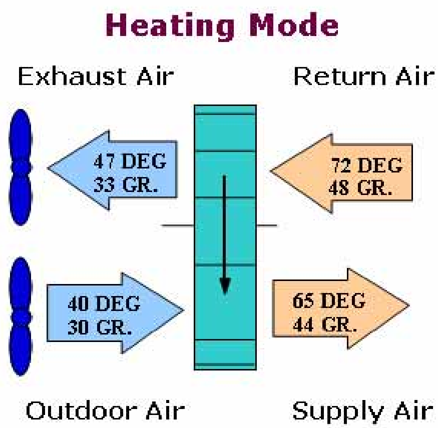
Typical Total Recovery Performance

Buffers the facility from outdoor air loads





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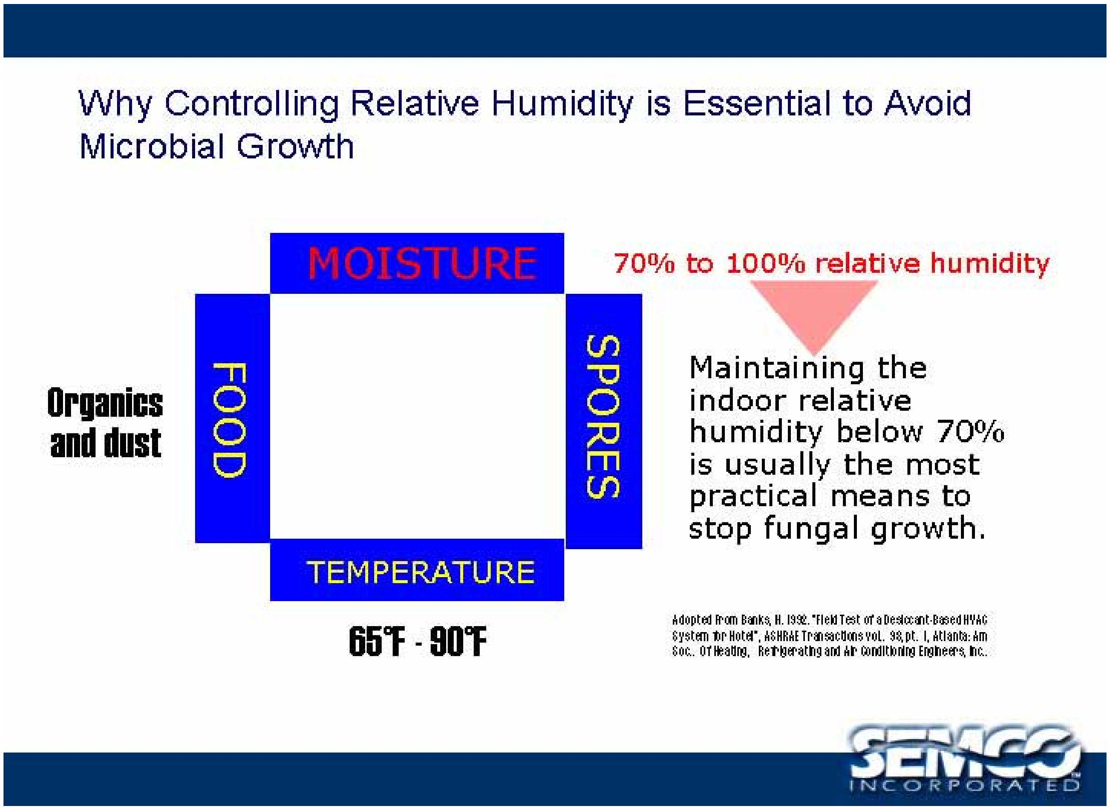
Why Controlling Relative Humidity is Essential to Avoid Microbial Growth
MOISTURE
70% to 100% relative humidity
Organics and dust
FOOD
SPORES
Maintaining the indoor relative humidity below 70% is usually the most practical means to stop fungal growth.
TEMPERATURE
65°F - 90°F
Adopted From Banks, H. 1992. "Field Test of a Desiccant-Based HVAC System for Hotel", ASHRAE Transactions Vol. 98, pt. 1, Atlanta: Am Soc. Of Heating, Refrigerating and Air Conditioning Engineers, Inc.
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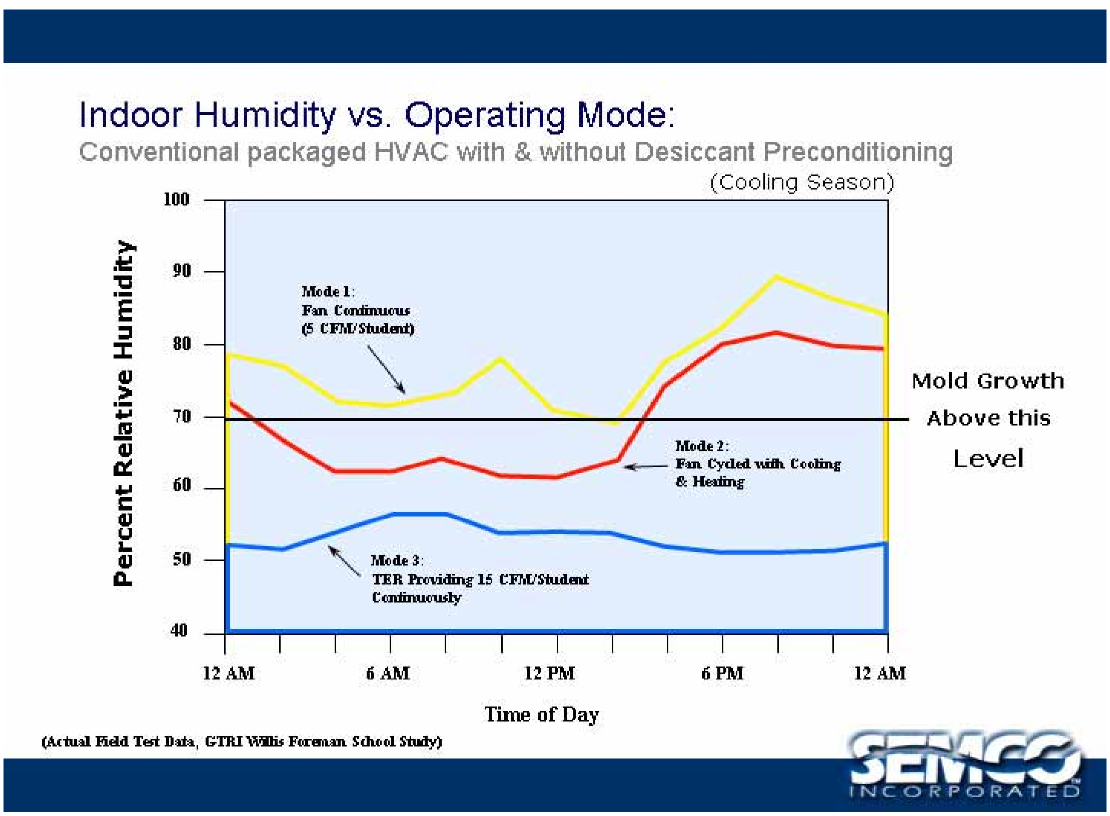
Indoor Humidity vs. Operating Mode:
Conventional packaged HVAC with & without Desiccant Preconditioning
(Cooling Season)
Percent Relative Humidity
100
90
80
70
60
50
40
Mode 1:
Fan Continuous
(5 CFM/Student)
Mode 2:
Fan Cycled with Cooling
& Heating
Mode 3:
TER Providing 15 CFM/Student
Continuously
Mold Growth
Above this
Level
12 AM
6 AM
12 PM
6 PM
12 AM
Time of Day
(Actual Field Test Data, GTRI Willis Foreman School Study)
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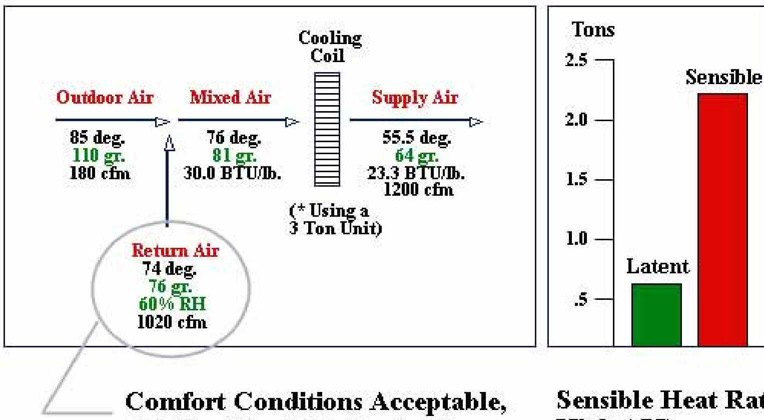
Conventional HVAC units are designed to perform with:

- Minimal outdoor air (15%)
- High sensible heat ratio



Comfort Conditions Acceptable, Relative Humidity Borderline, Minimal Outdoor Air Volume (15%)

Sensible Heat Ratio High (.75)

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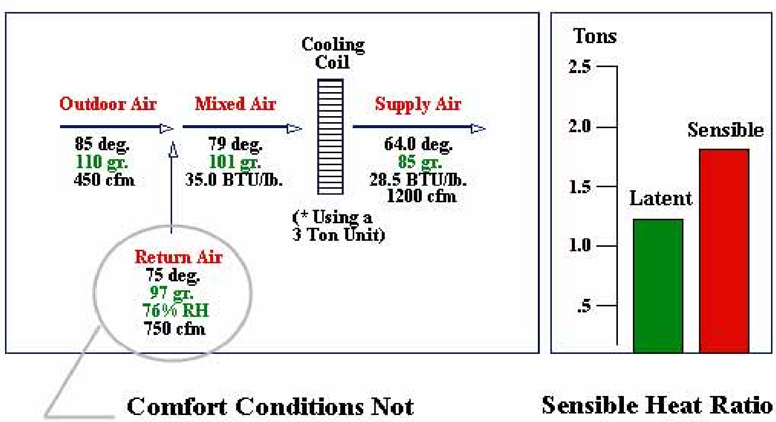
Conventional HVAC units do not perform well with:

- Increased or continuous outdoor air
- High latent to sensible heat ratios



Comfort Conditions Not Acceptable, Humidity Unacceptable, Outdoor Air Volume as per ASHRAE (38%)

Sensible Heat Ratio Low (.58)

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Why Outdoor Air Must Be Supplied Continuously

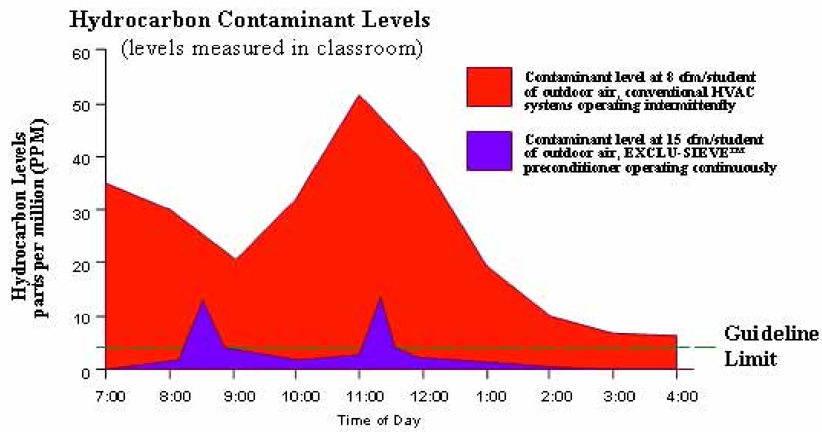

Figure 1: Georgia Tech IAQ test results document the need for the ASHRAE Standard in school facilities. Note the difference in time required to purge contaminants and the level of buildup with intermittent operation.

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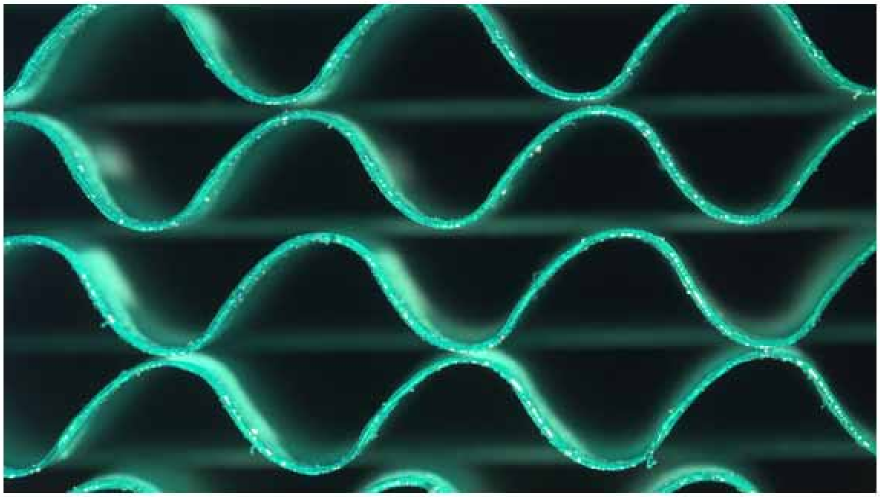
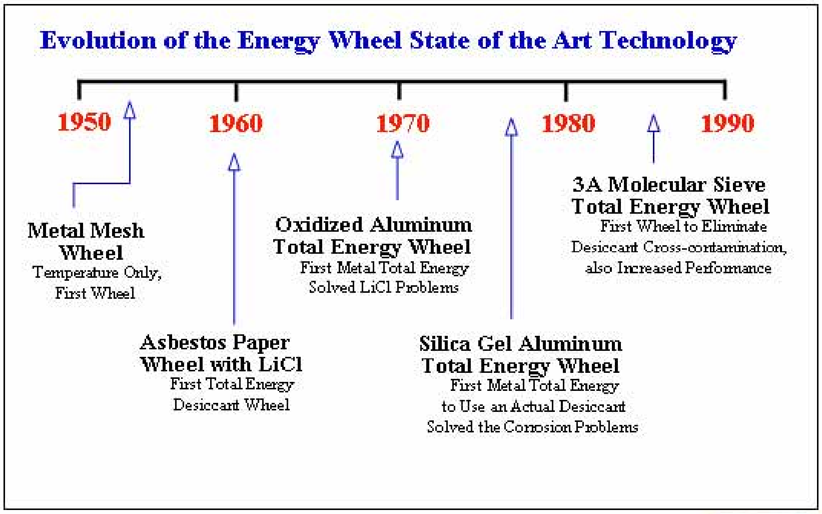
Fluted Media: Face Coating

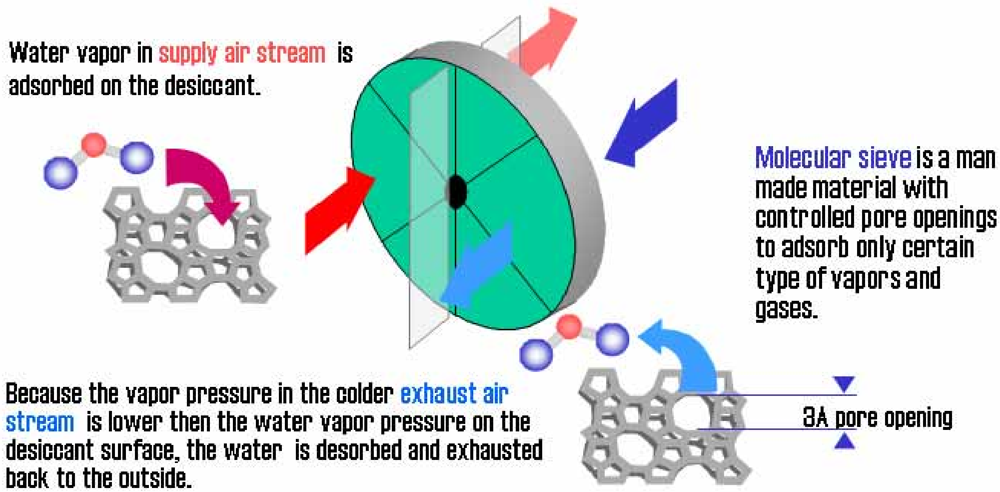


Evolution of Energy Recovery Wheels: "Brillo Pad to Molecular Sieves"



Molecular Sieves: How does it work?

Summertime Operation



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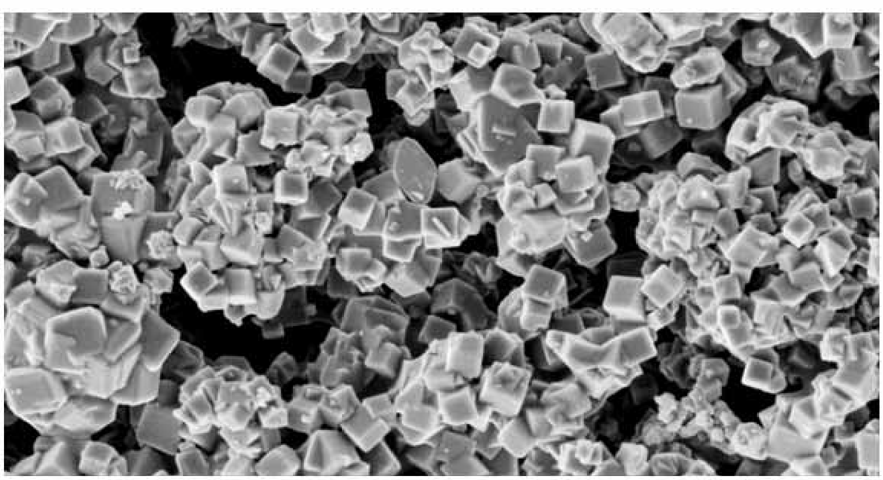
Molecular Sieve Desiccant Coating

(SEM 10,000 X)



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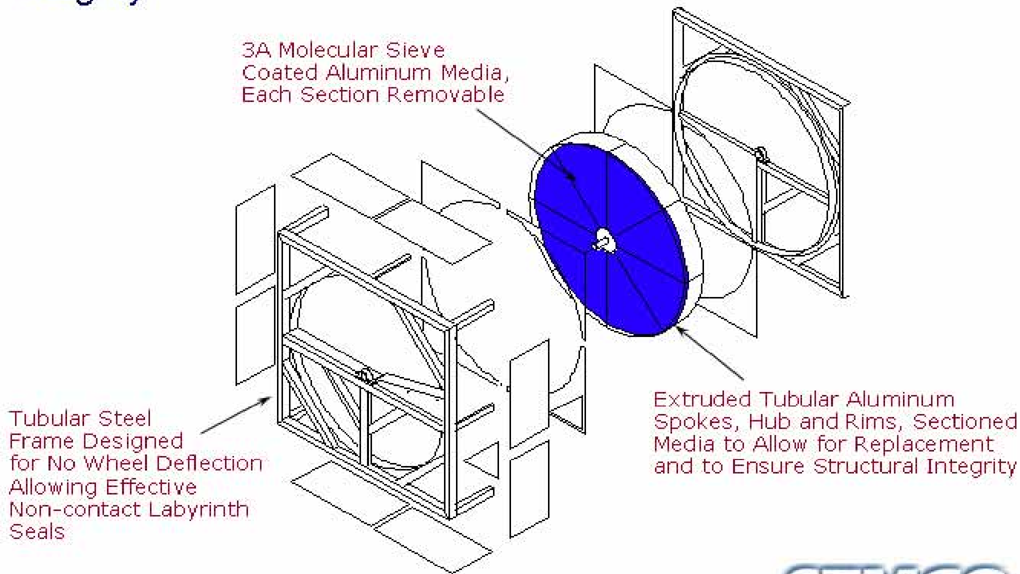
SEMCO Wheel is Designed for Reliability and Structural Integrity



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Wheel Cassette:

Before Media Installation

Complete Cassette

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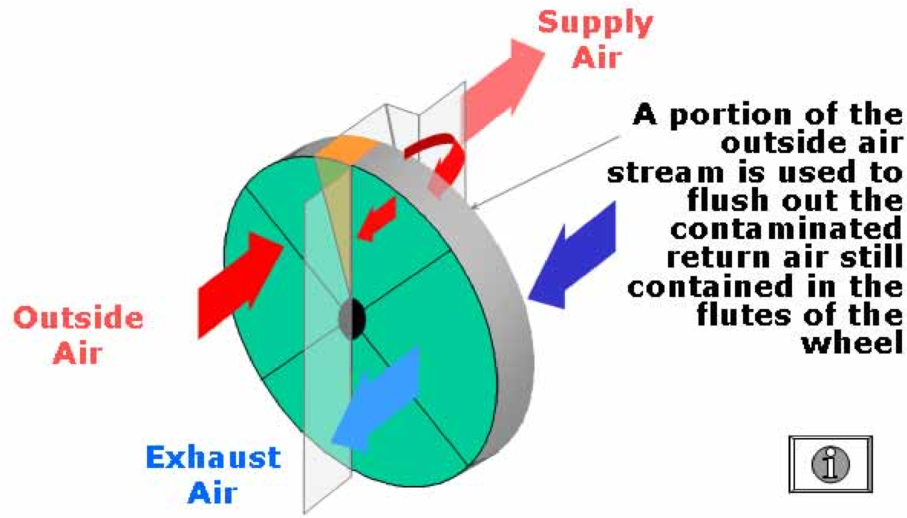
Purge Assures No Re-entrainment



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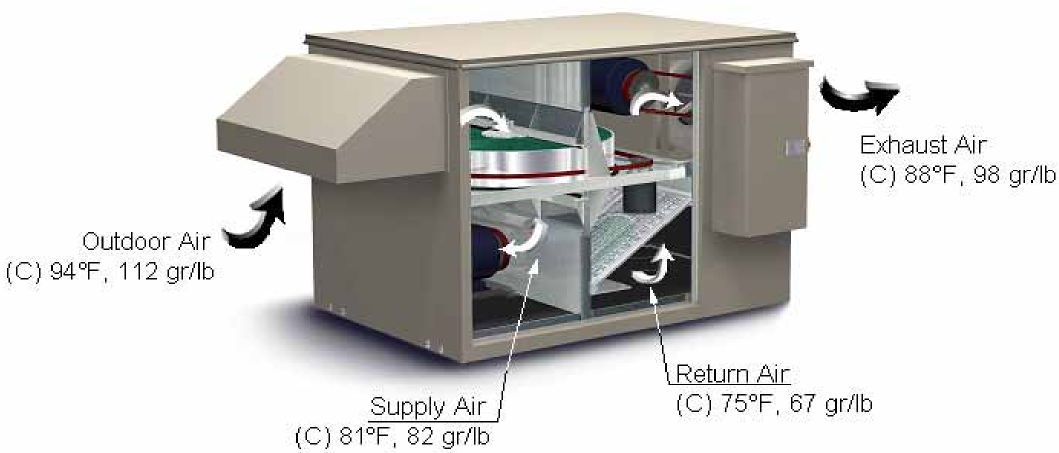
FV Series: How it Works



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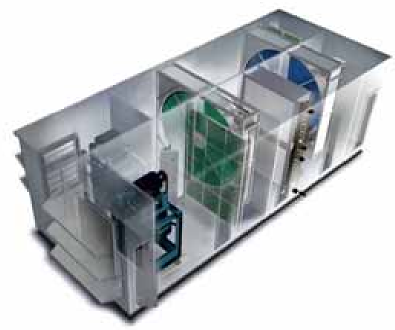
Applied Systems Overview



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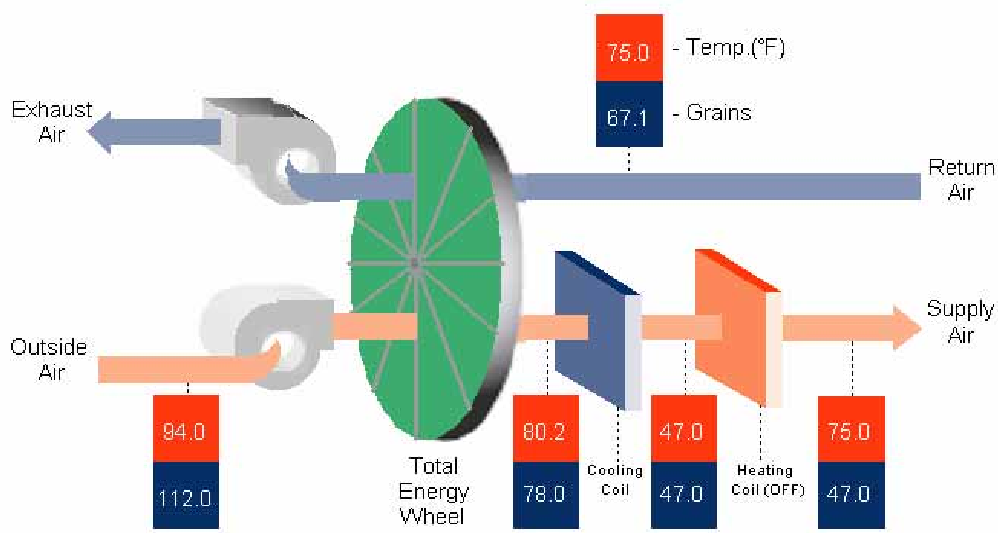
EPCH Solution



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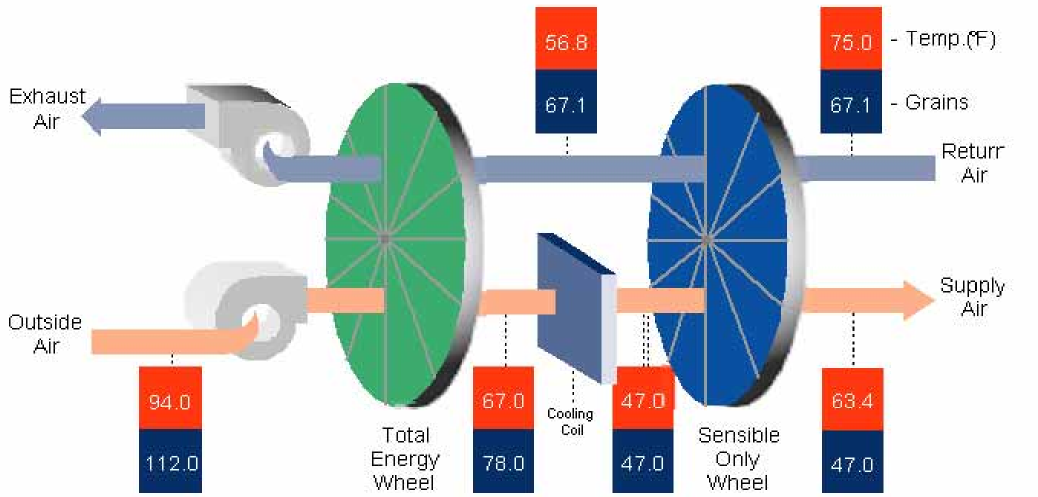
EPD Solution



Total Energy Recovery Case Histories

Only SEMCO has the expertise to produce both total energy wheels & systems

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Georgia Tech Olympic Dormitory

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Georgia Tech – Energy Recovery Details

- 43,000 cfm of outdoor air through 4 EPD systems
- Dehumidified outdoor air (cooling) and humidified outdoor air (heating) delivered at a space neutral temperature
- 7 years of successful operation

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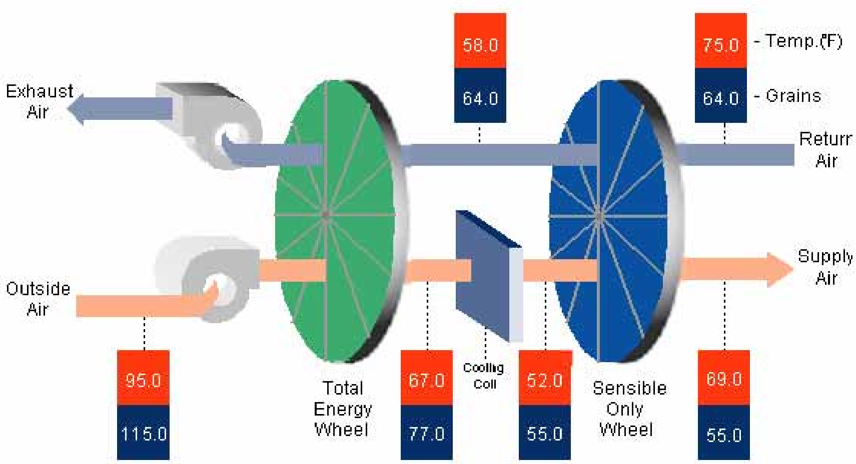
Georgia Tech – Cooling Mode (EPD)



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Georgia Tech – Benefits Recognized

- Economical application of constant volume, 100% outdoor air system to deliver preconditioned ventilation air to the corridors.
- Decoupled outdoor air and some space latent load from conventional room HVAC units, improved space humidity control.
- Significant reduction in first cost, operating cost and life cycle cost. Provided exceptional ROI.
- Reduced chiller/boiler capacity requirements.
- Free heating season humidification.

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Georgia Tech – Economic Summary

Annual Energy Savings Summary

	Conventional System	EXCLU-SIEVE™ Preconditioning
Energy Cost for outdoor air heating and cooling	$80,670/year	$22,830/year
Demand Charges for outdoor air	$22,420/year	$13,020/year
Total Energy Cost	$103,090/year	$35,850/year
Energy Savings with Total Energy Preconditioning		$67,240/year

NOTES:
1. Supply air 43,000 cfm, exhaust air 28,800
2. Electric cost is $.055/KWH, gas at $.55/Therm
3. Based on a 24 hr/day, 7 day/week operation
4. Assumes preheat to 68 degf. during winter with hot water
5. Assumes cooling to 52 degf. during cooling season with reheat to 68 degf.

First Cost Comparison Summary

	Conventional System	SEMCO EPD Preconditioning
Cost of 3 Energy Recovery or AHU Preconditioners	$81,700	$202,900
Installation/ Ductwork	$63,500	$69,000
Chiller, Cooling Tower & Boiler	$171,200	$66,000
Chilled Water Piping Credit	$0	($33,000)
Total Installation Cost	$316,400	$304,900
EXCLU-SIEVE™ Preconditioning First Cost Savings		$11,500

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Applying a SEMCO Total Energy Recovery System to a Large Office Facility:

Analyzing the Decision After 10 Years of Operation

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1100 Peachtree - Project Specifics

- 33 Story Headquarters Facility in Atlanta
- Designed to Meet ASHRAE 62-89 Guidelines
- Required 52,000 CFM of Outdoor Air, 31,000 CFM of Exhaust Air from Toilet Areas
- Utilized Desiccant Based Total Energy Recovery Preconditioning
- Preconditioned Outdoor Air Delivered to VAV Air Handling Units Located on Each Floor

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1100 Peachtree – Benefits Recognized

- Reduced annual energy consumption by $51,000 while maintaining IAQ.
- Reduced project first cost by cutting chiller capacity by 137 tons and eliminating a 600 KW electric preheating coil.
- Maintains a constant delivery of outdoor air to occupied spaces as the VAV system modulates the amount of return air.
- Free winter time humidification, reduced cooling coil condensate by 1,300 lbs/hr at design conditions.

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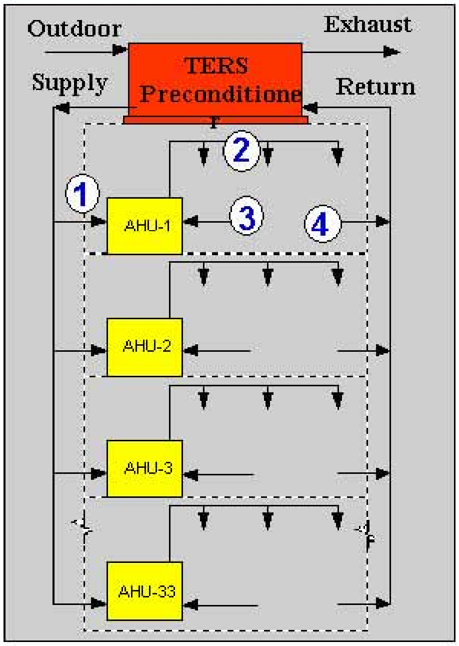
Schematic:

- Conditioned outdoor air leaves the TERS and is delivered to the VAV units (1).
- The VAV unit mixes recirculated room air (3) and outdoor air (1) and delivers it to the space (2).
- Air from toilet areas and janitors closets pulled through the TERS and exhausted (4).



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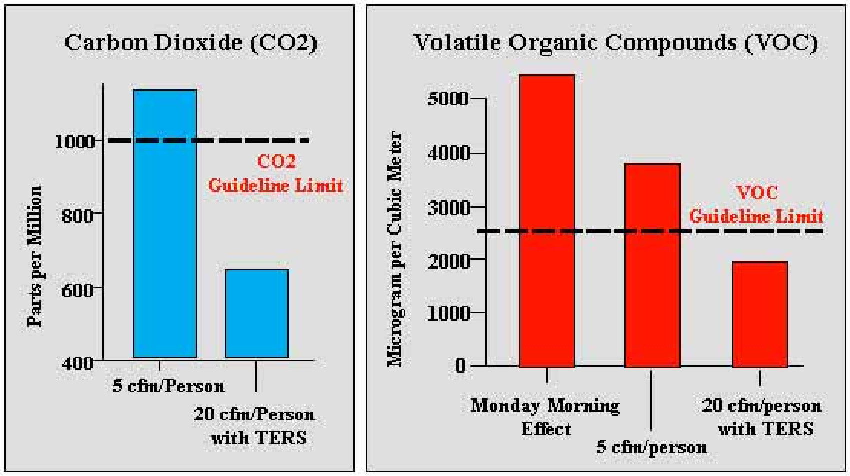
Independent IAQ Investigation Supports the ASHRAE 62 Guidelines



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1100 Peachtree – Economic Summary

Annual Energy Savings Summary

	Conventional System	TERS Preconditioning
Energy Cost for outdoor air heating and cooling	$45,500/year	$23,400/year
Demand Charges for outdoor air	$36,200/year	$7,200/year
Total Energy Cost	$81,700/year	$30,600/year
Energy Savings with Total Energy Preconditioning		$51,100/year

NOTES:
1. Supply air 52,000 cfm, exhaust air 31,200
2. Electric cost is $.07/KWH plus $8/KW demand charge
3. Based on a 12 hr/day, 5 day/week operation
4. Assumes preheat to 40 degf. during winter with electric
5. Assumes cooling to 58 degf. during cooling season
6. Savings would have been greater had exhaust equal supp

First Cost Comparison Summary

	Conventional System	TERS Preconditioning
Cost of Energy Recovery or AHU Preconditioner	$56,000	$110,000
Installation/ Ductwork	$28,000	$23,000
Chiller & Cooling Tower	$91,000 (260 tons)	$43,000 (123 tons)
Electric Preheat Coil	$7,000 (600KW)	$0 (0KW)
Total Installation Cost	$182,000	$176,000
Total Energy Recovery Preconditioning First Cost Savings		$6,000

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Interview with Building Engineer

- Rated overall performance as excellent, minimal maintenance, high reliability.
- Maintenance required:
  - Quarterly filter changes;
  - Semi-annual inspection of belts, gear reducers;
  - Annual bearing lubrication.
- Would highly recommend this design approach for future buildings.

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Problems Over 9 year History

- Low cost substitute filter pulled out of filter rack during driving rain and damaged wheel media requiring replacement.
- Vane axial fan required service one time for worn part.
- Rebuilt one energy wheel gear reducer, replaced belts two times.

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1100 Peachtree – Evaluation Summary

- Benefits promised by the technology at the design phase have been recognized over time at the 1100 Peachtree Building.
- Air quality within the building is excellent.
- Owner has saved approximately $500,000 in energy cost over the life of the project.
- No degradation to recovery performance over time (checked after 6 and 9 years).

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Source for Additional Information

- Office Building IAQ Investigation
  - ✍ ASHRAE IAQ'91 Proceedings: Healthy Buildings, "Does a total energy recovery system provide a healthier environment?" Pages 74-76. C.W. Bayer and C.C. Downing

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Johns Hopkins Ross Research Facility

11 Years of Successful Operation

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Ross Building - Project Specifics

- 300,000 cfm of combined laboratory/hood exhaust
- 10 air changes per hour, constant volume system
- Eight SEMCO 3A molecular sieve coated total energy recovery wheels (14' diameter)
- 11 years of successful operation

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Ross Building – Benefits Recognized

- Economical application of constant volume, 100% outdoor air system to laboratory (preferred by the Head of Health and Safety).
- Significant reduction in first cost, operating cost and life cycle cost. Provided exceptional ROI.
- Reduced chiller/boiler capacity requirements allowed for the use of central plant utilities.
- Improved humidity control, reduced condensate on cooling coils by 65% and size of steam to steam humidifiers.
- Resolved “freeze-stat” alarms with frozen coils.

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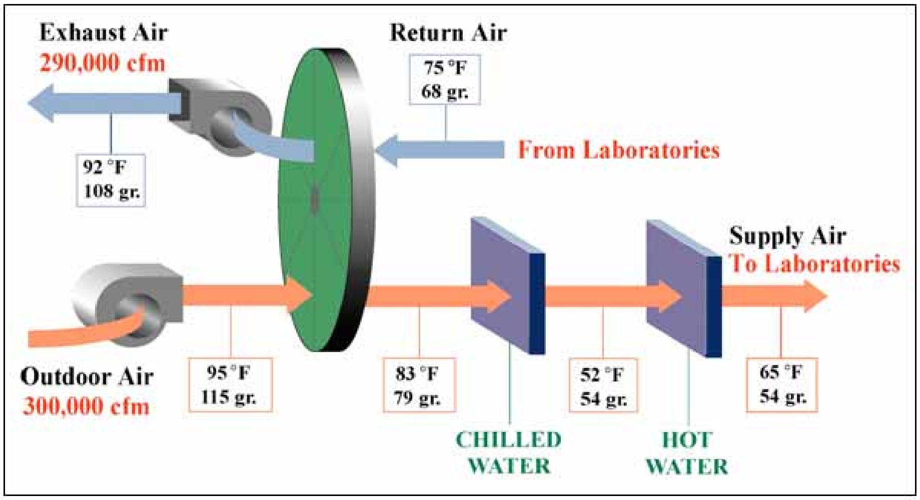
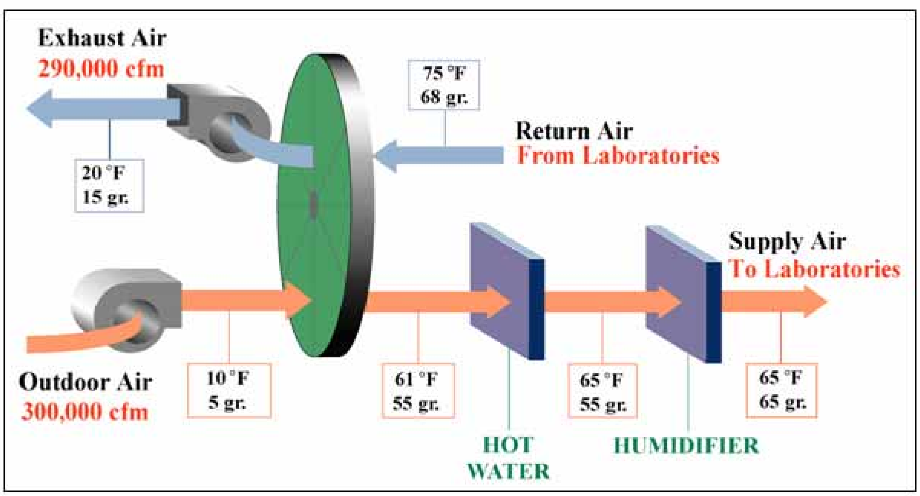
Ross Building – Cooling Mode



SEMCO INCORPORATED

Ross Building – Heating Mode



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Ross Building – Economic Summary

Annual Energy Savings Summary		
	Conventional System	EXCLU-SIEVE™ Preconditioning
Energy Cost for outdoor air heating and cooling	$1,070,500/yr.	$503,300/yr.
Demand Charges for outdoor air	$151,800/yr.	$73,800/yr.
Total Energy Cost	$1,222,300/yr.	$577,100/yr.
Energy Savings with Total Energy Preconditioning		$645,200/year

NOTES:
1. Supply air 300,000 cfm, exhaust air 280,000
2. Electric cost is $.045/KWH, gas at $.45/Therm
3. Based on a 24 hr/day, 7 day/week operation
4. Reheat to 75 degf. during winter with humidification
5. Assumes cooling to 52 degf. during cooling season
6. Demand charges are $14.42 from June to September

First Cost Comparison Summary		
	Conventional System	EXCLU-SIEVE™ Preconditioning
Cost of Energy Recovery or AHU Preconditioner	$450,000	$1,056,900
Installation/ Ductwork	$235,000	$295,000
Chiller & Cooling Tower	$3,158,400 (2632 tons)	$1,536,000 (1280 tons)
Boiler and Piping	$286,300 (818 HP)	$71,400 (204 HP)
Total Installation Cost	$4,129,700	$2,959,300
EXCLU-SIEVE™ Preconditioning First Cost Savings		$1,170,400

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Ross Building – Life Cycle Analysis

- SEMCO total energy recovery wheels resulted in a first cost savings of $1,170,400.
- Provided a positive present value cash flow of $6,959,600 based on 20 year life cycle.
- Will provide estimated energy savings in the amount of $15,307,500 over the 20 year life cycle analysis period.

Assumes: inflation at 2.5% and cost of capital of 10%, no taxes

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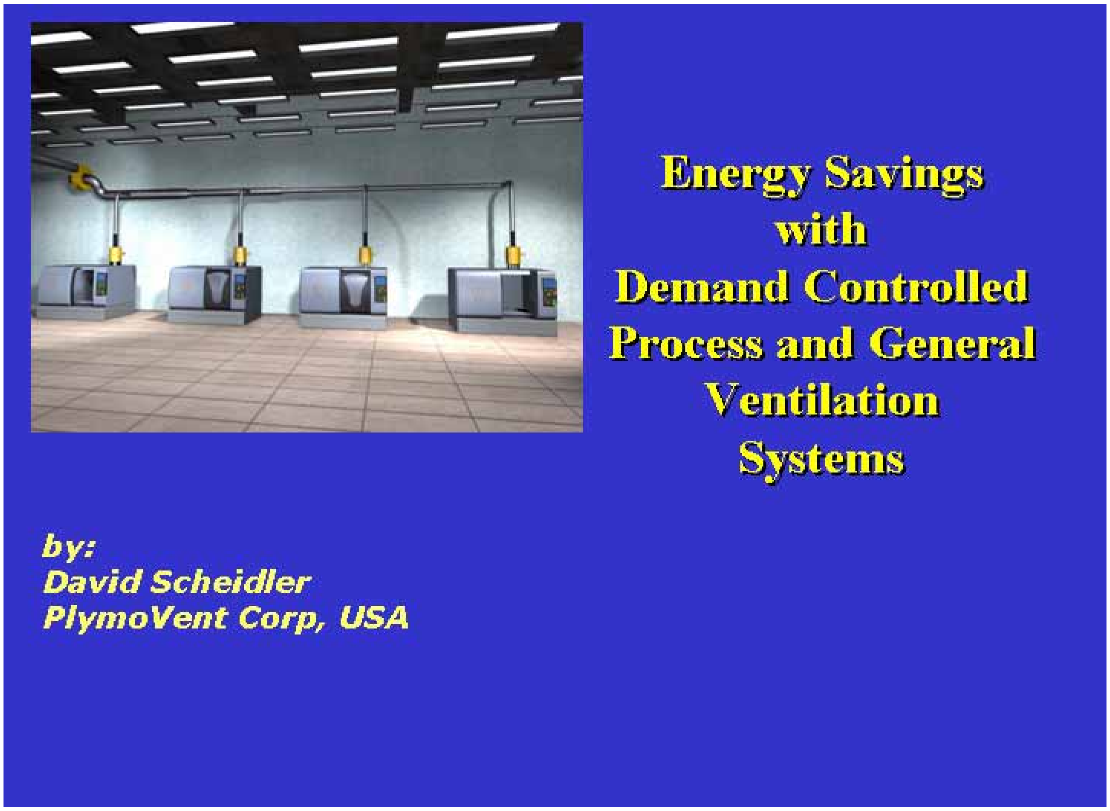
Energy Saving with Demand Controlled Ventilation

Presenter: Mr. David Scheidler. Plymovent



WORLD WIDE ENERGY DEMAND IS UNDER ATTACK!

- Not since the OPEC oil embargo has the world's energy supply been in question.
- The war on terrorism and conflicts in the Middle East will inevitably raise energy prices.
- The failure to continue to explore alternate energy sources in the past two decades has continued the demand on fossil fuel energy to supply most countries electric power needs.

HOW WILL YOU HANDLE THE ENERGY COST INCREASE ? HISTORY REPEATS ITSELF. IN THE LATE 70'S THE OPEC OIL EMBARGO DOUBLED MOST ENERGY COSTS.

- **1979** gasoline costs in the United States were **.37 cents** per imperial gallon prior to the oil embargo.
- **1980** gasoline prices drastically rose to **.95 cents** per imperial gallon.
- This increase in fossil fuel demand left the US consumer with an increase in energy costs which dramatically effected corporate profits and inflated the general cost of living.
- **Energy prices rose nearly tripled**.
- **Winter of 2001**, gasoline costs in the US were **$1.00 per** imperial gallon. This meant there was little increase in the change of the price of crude oil from the year of 1980 to the winter of 2001.
- **Summer of 2001**, gasoline cost in the US rose in less then 6 months to a **$1.75 per** imperial gallon.
- The result of this dramatic increase has directly **effected corporate profits, initiated surge charges for peak demand users**, and states like California **created rolling blackouts and interruption** of power.

DEMAND CONTROL VENTILATION IS A SOLUTION FOR SAVINGS.

Process ventilation applications

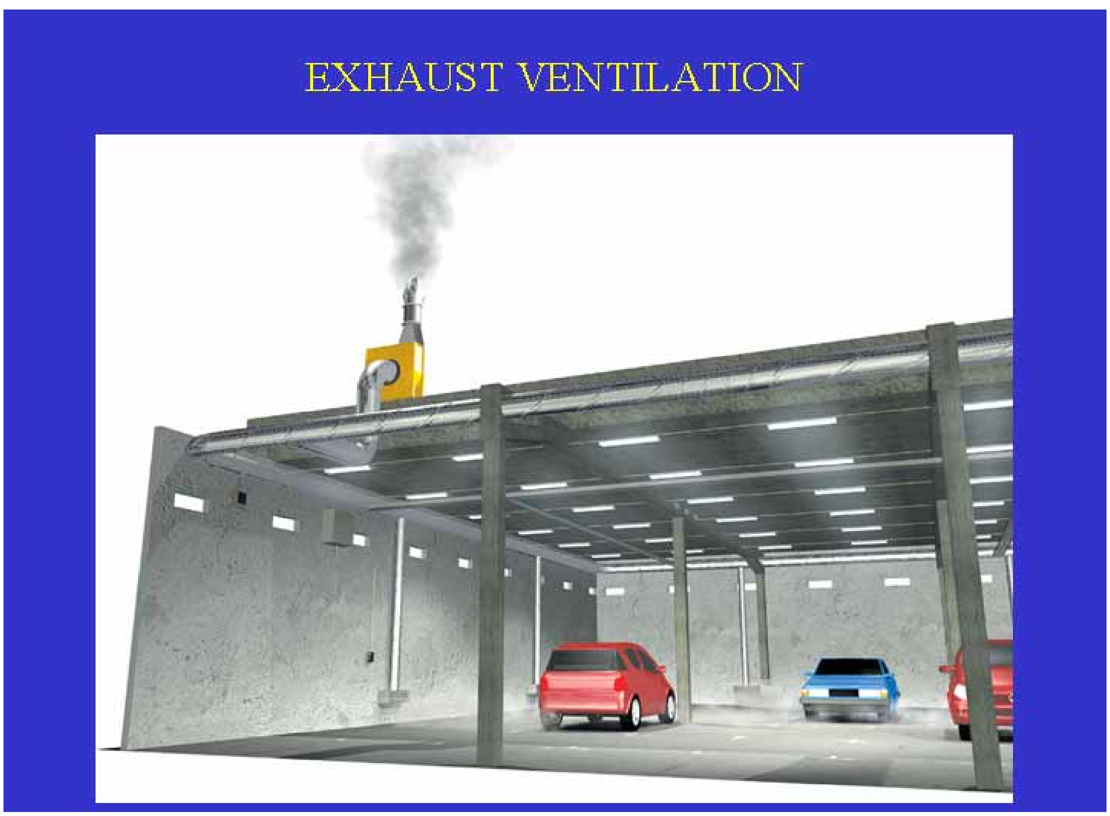
- Machining processes
- Welding processes
- Grinding processes
- Laser and plasma cutting processes
- Finishing processes
- Vehicle tune-up processes

General ventilation applications

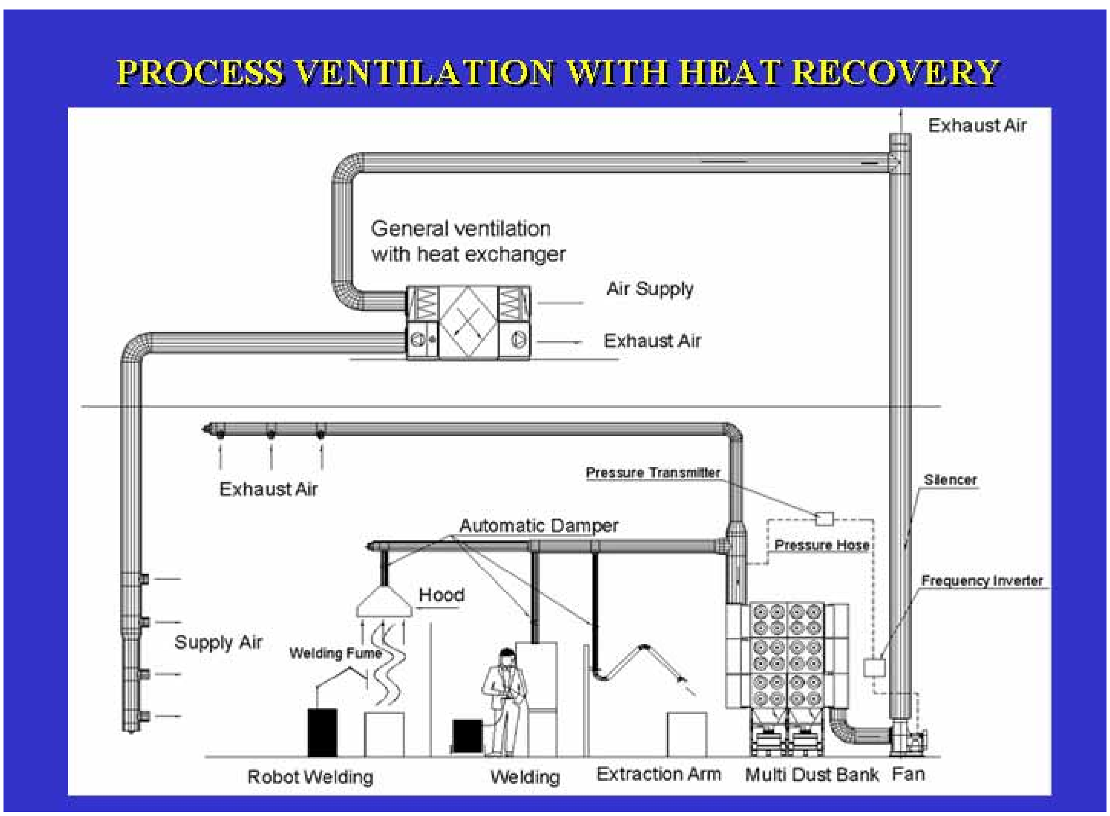
- Indoor air quality control
- Vehicle emissions control
- General exhaust
- Displacement ventilation

PROCESS VENTILATION

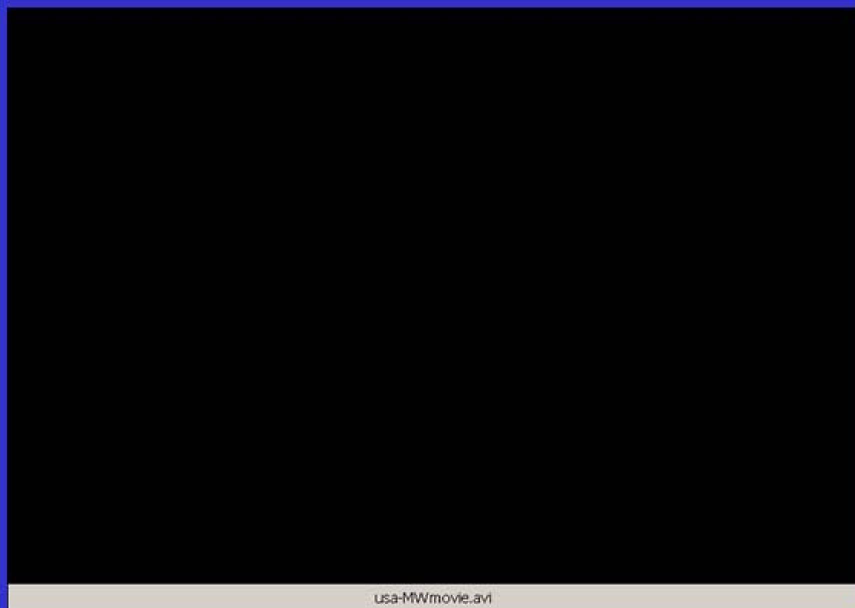

DISPLACEMENT VENTILATION


EXHAUST VENTILATION


FUMES/DUST/ODORS VENTILATION


PROCESS VENTILATION WITH HEAT RECOVERY
Exhaust Air
General ventilation
with heat exchanger
Air Supply
Exhaust Air
Exhaust Air
Pressure Transmitter
Silencer
Automatic Damper
Pressure Hose
Frequency Inverter
Hood
Supply Air
Welding Fume
Robot Welding
Welding
Extraction Arm
Multi Dust Bank
Fan

MACHINE TOOL PROCESS WITH DEMAND CONTROLS



TYPICAL CONTROL SENSOR TYPES

- Pressure differential sensor
- Infra-red light sensor
- Inductive electrical sensor
- Particulate sensor
- Relative humidity sensor
- CO sensor
- Hydrogen sensor
- Temp. sensor
- And many others

PEAK DEMAND EVALUATION

When designing a demand controlled ventilation system it is important to evaluate the peak demand usage factor of the system.

High demand - small ventilation systems or robotic systems usually exhibit higher peak demand.

Low demand – large manual or semi-automatic systems usually exhibit lower peak demand.

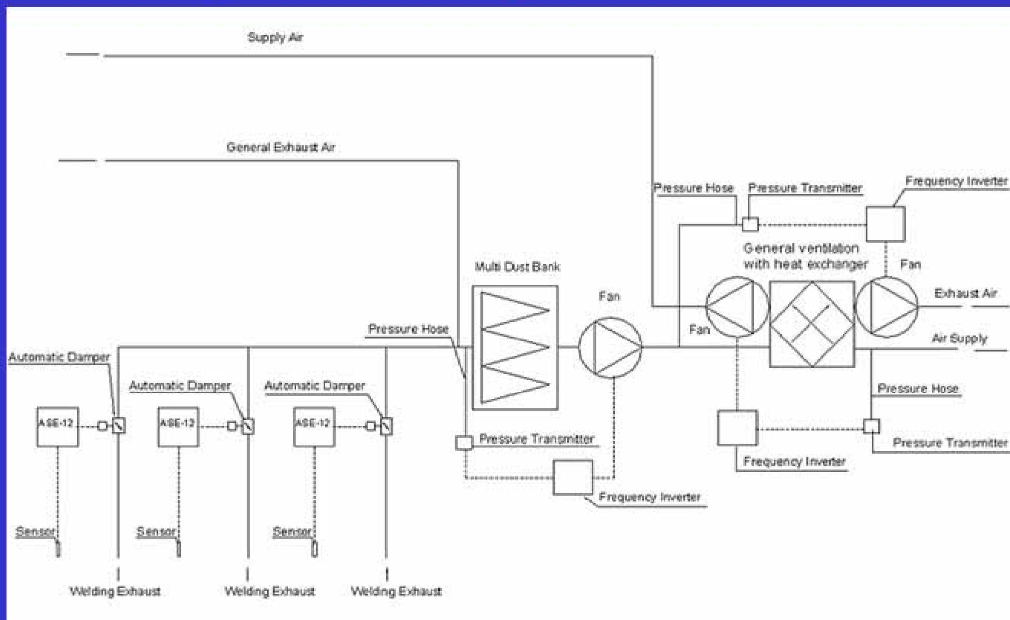
Example of demand :

1-2	**workstations**	**- 90-80% usage**
3-4	**workstations**	**- 70-80% usage**
5-8	**workstations**	**- 55-70% usage**
10+	**workstations**	**- 45-50% usage**

HOW ARE SAVINGS ACHIEVED ?

- **Lower energy consumption** – energy consumption is reduced since the ventilation system only operates when required by the demand of the process. It will also operate only for the designated air delivery which is required by process demands.
- **Lower maintenance costs** - maintenance cost will be reduced since the system will not be required to operate at 100% capacity at all times. This will reduce the quantity of filter elements and their frequency of replacement.
- **Lower operating costs** – operating costs will be reduced by more efficient energy saving blower motors which in turn are energy managed by demand controllers which are interfaced with frequency inverters.
- **Lower installation costs** – installation costs are reduced by reducing the overall size of the system and its related components such as electrical wiring, motor starters, size of ductwork, and the need for fire suppression.
- **Lower initial purchase costs** – since few manufacturing processes operate at 100% demand, a savings will be achieved by reducing the overall air volume of the system and its filtering systems.

Controls, schematic drawing



Energy Saving Analysis

Average temperature on location C	6 degrees C
Ambient air temperature	-15 C
Two shift operation hours	3520h
Year hours	8760h
Energy required to heat 1 m^3 air 1 degree C	0,348W
Min. required efficiency on heat exchanger	50%

	Pcs	Airflow per point m3/h	Hours /year	Without controls and heat exchanger Usage %	Without controls and heat exchanger Total airflow/h	With controls and w/o heat exchanger Usage %	With controls and w/o heat exchanger Total airflow/h	With controls and heat exchanger Usage %	With controls and heat exchanger Total airflow/h
Extraction arms manual welding	5	1 000	3520	100	5 000	30	1 500	30	1 500
Suction tables manual welding	24	1 800	3520	100	43 200	30	12 960	30	12 960
Suction hoods robot welding	8	1 800	3520	100	14 400	80	11 520	80	11 520
General ventilation	1	28 000	8760	100	28 000	100	28 000	100	28 000
Total airflow					90 600		53 980		53 980
Energy consumption per year process ventilation				kWh	1 063 000		445 885		156 153
Energy consumption per year general ventilation				kWh	1 195 000		1 195 000		421 431
Power consumption on fan motor				kWh	497 340		419 724		419 724
Total				kWh	2 755 340		2 060 609		997 308
Savings with control equipment				kWh			694 731		
Savings with control equipment and heat exchanger				kWh					1 758 032

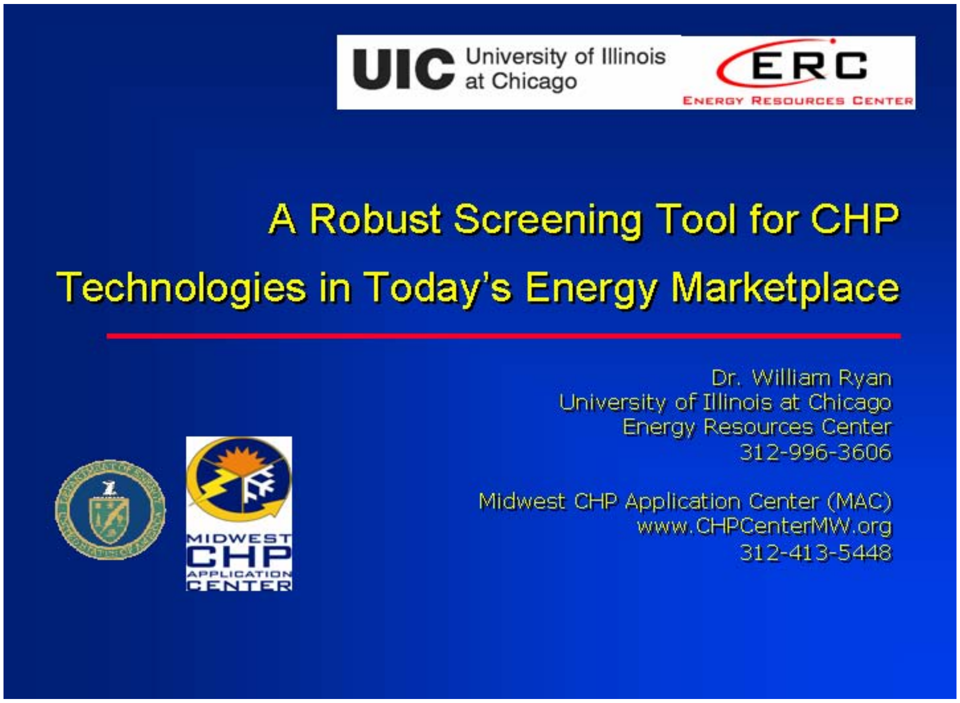
WELDING PROCESS WITH DEMAND CONTROLS AND NOTIFICATION SYSTEM

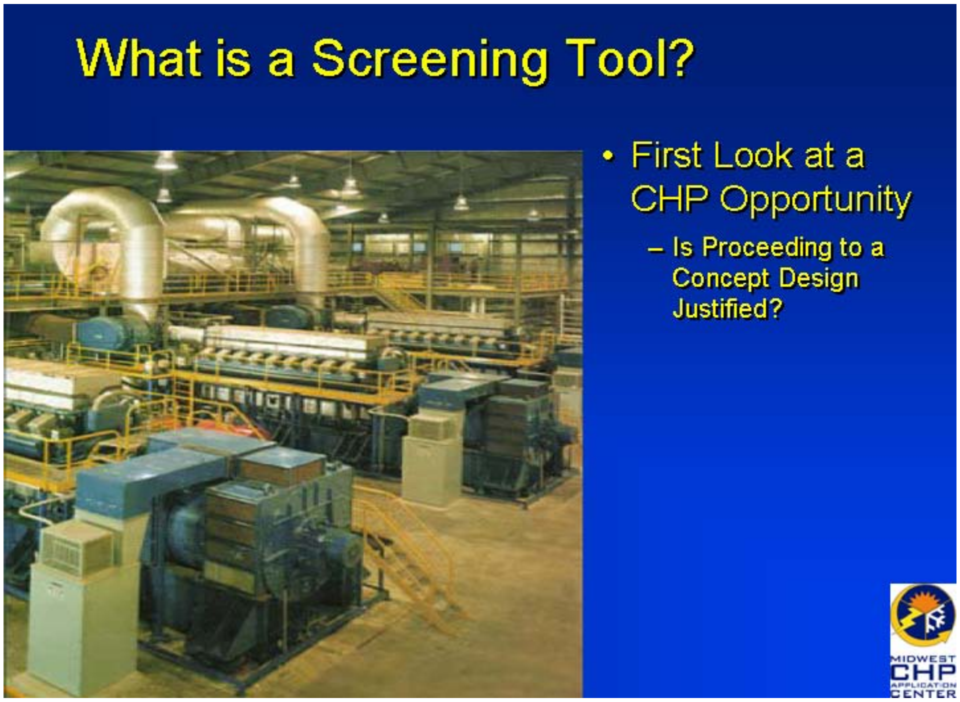
QUESTIONS FROM THE AUDIENCE


THANK YOU FOR YOUR PARTICIPATION.
• If you have any questions or comments, please email them to wlutz@plymoventusa.com
• Or Call 908-209-2096

A Robust Tool for Screening. Tool for Combined Heat and Power Technologies in Today's Energy Marketplace

Presenter: Mr. William Ryan. University of Illinois in Chicago, ERC.





How Does it Need to be Structured?

- Quick and Easy-to-Use
- Handle the Level of Detail Available on the Application
  - Might Be a Basic Architectural Description of a New Building, or
  - An Existing Building with a Historic Record of Energy Consumption
- The Market Today Expects More Accuracy and Sophistication in Screening Tools than in the Past

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What is the Most Common Pitfall of Existing Screening Tools

- Averaging !
  - Energy Analysis Often has this Inaccuracy
  - In CHP or any Heat Recovery System – It is Lethal
- Unfortunately – It is Also Nearly Universally Done

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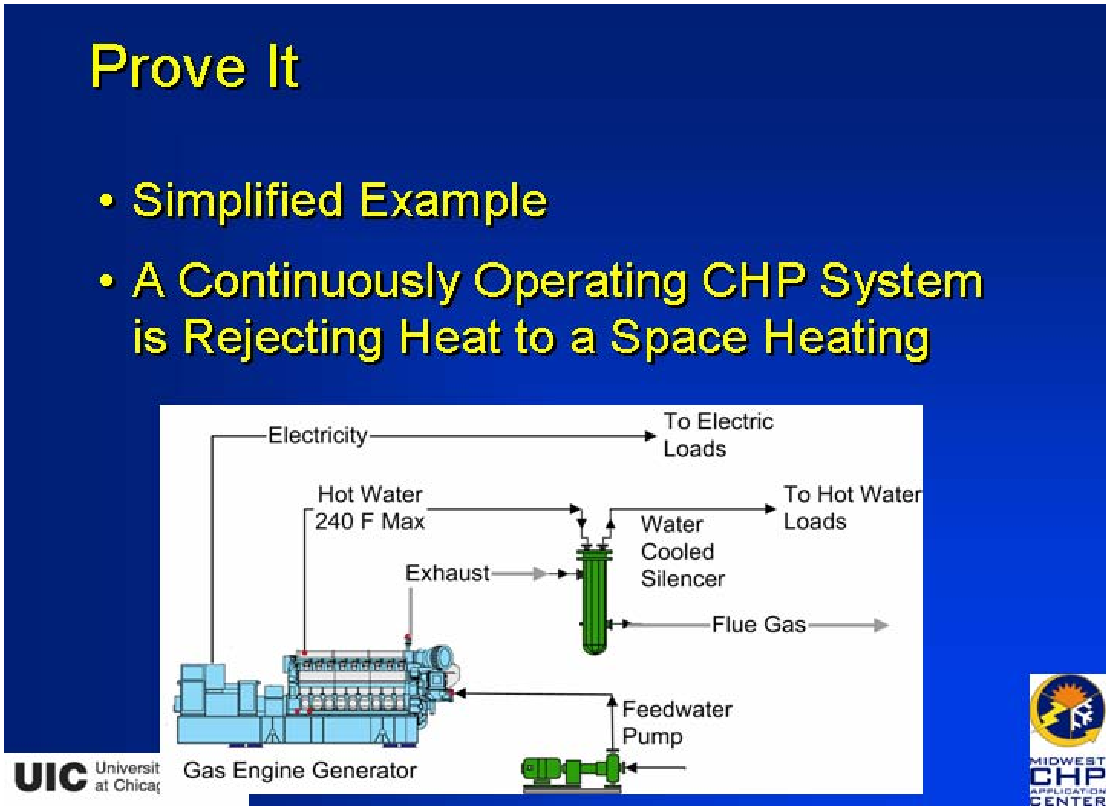
Prove It
• Simplified Example
• A Continuously Operating CHP System is Rejecting Heat to a Space Heating
Electricity
To Electric Loads
Hot Water 240 F Max
To Hot Water Loads
Water Cooled Silencer
Exhaust
Flue Gas
Feedwater Pump
Gas Engine Generator
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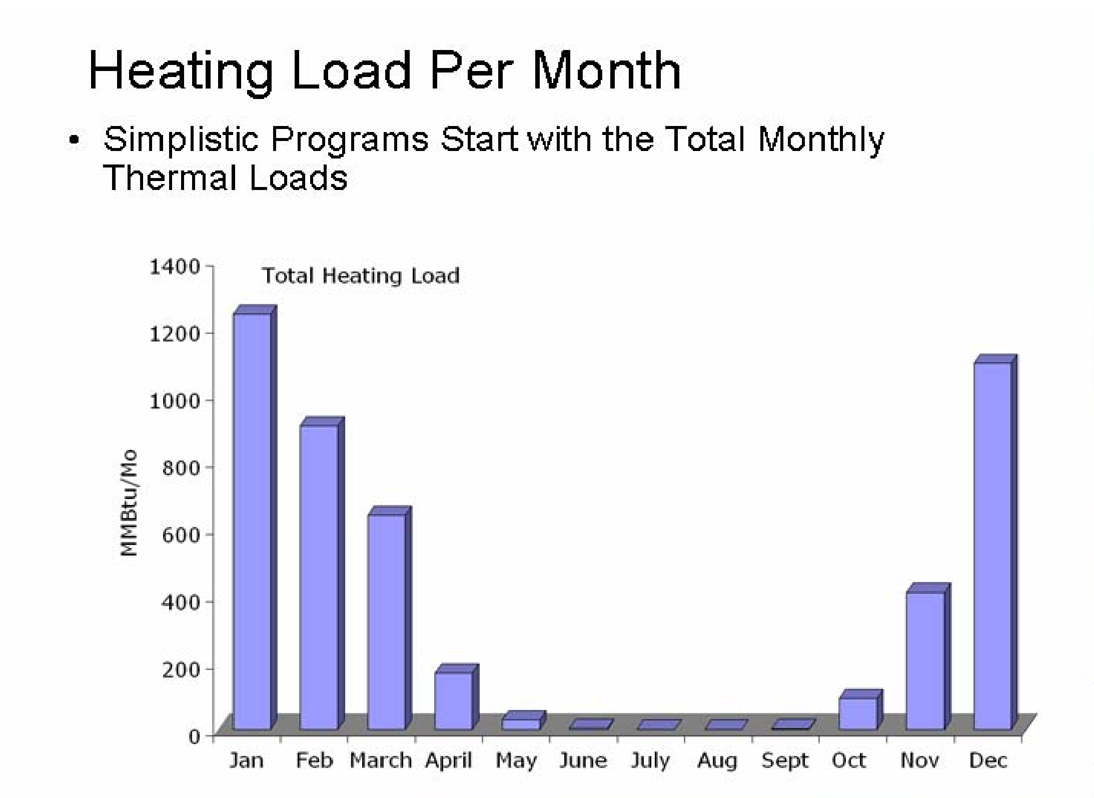
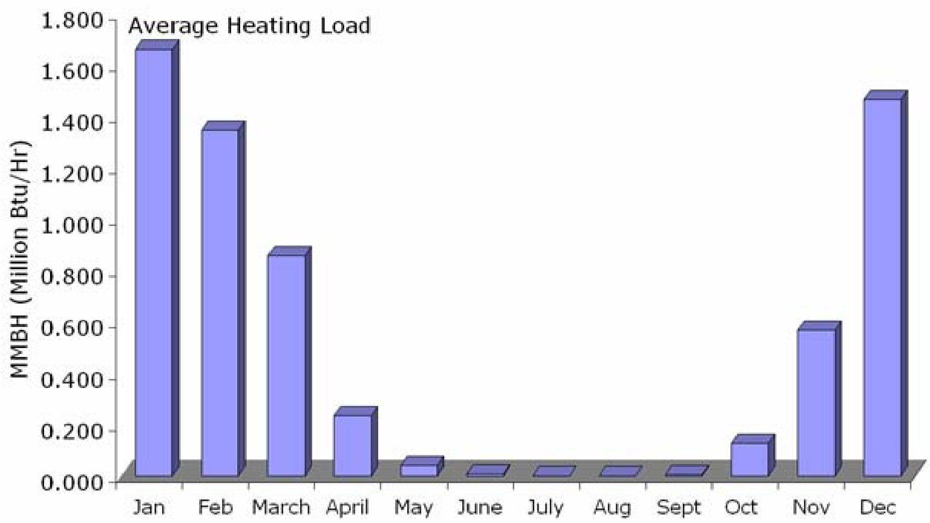

Heating Load Per Month
• Simplistic Programs Start with the Total Monthly Thermal Loads
Total Heating Load
MMBtu/Mo
0
200
400
600
800
1000
1200
1400
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec

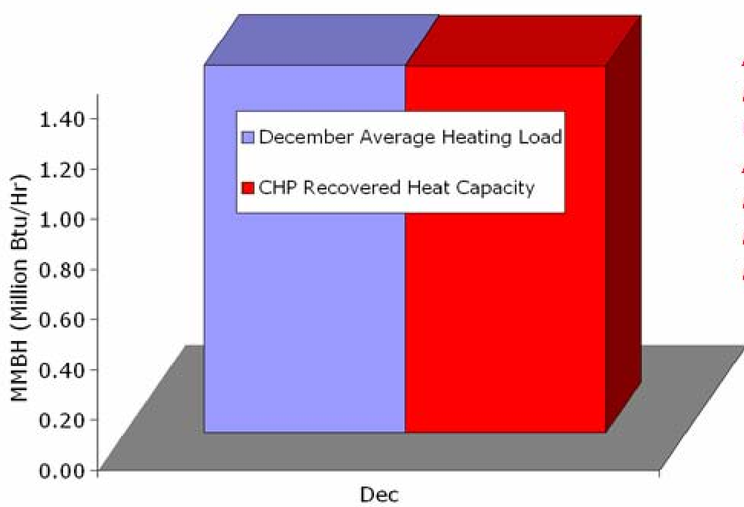
Average Heating Load

- This Amounts to Assuming the Heating Load is Split Evenly Across the Month



Average Heating Load

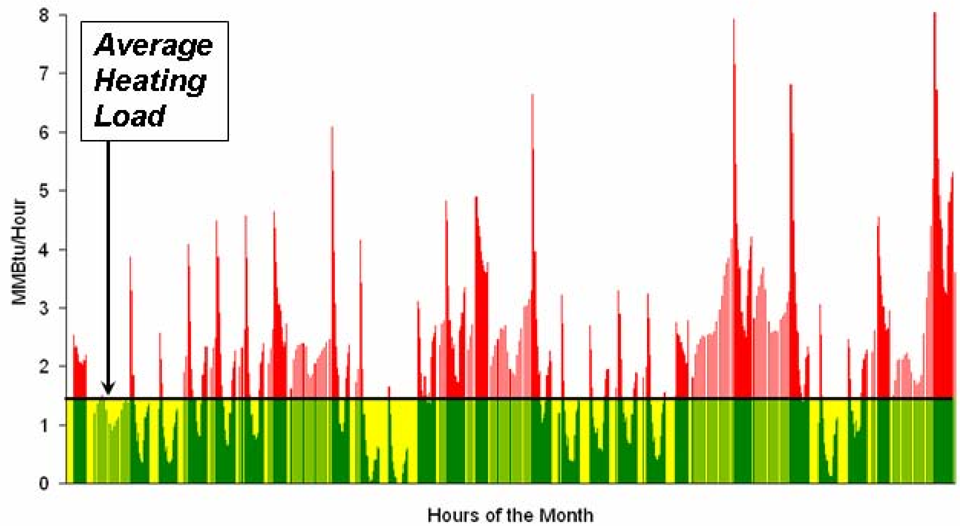
- Lets Take a Look at December and Assume that the Recovered Heat Output Capacity of a CHP System Equals the Average Load in December



Averaging Programs Have No Choice But to Assume the Recovered Heat Meets the Heating Load

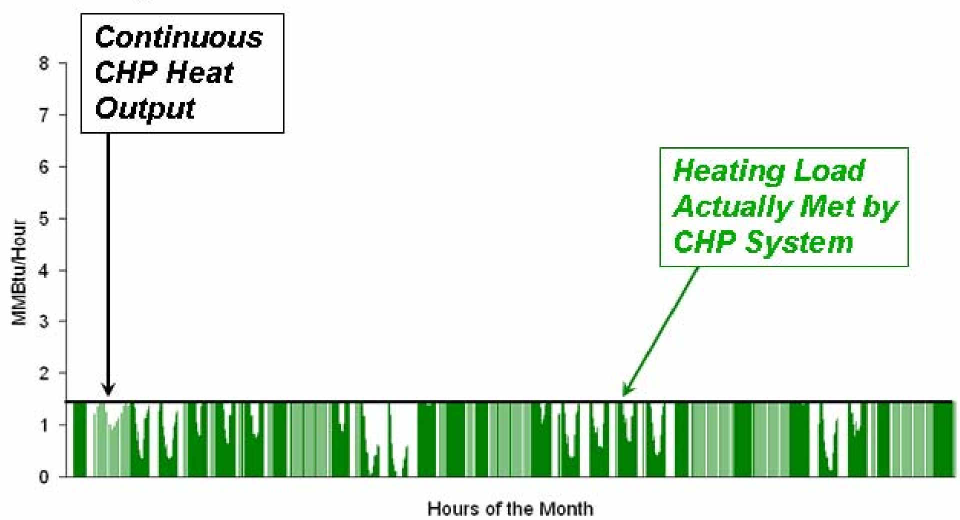
Nothing Could Be Further From the Truth !!

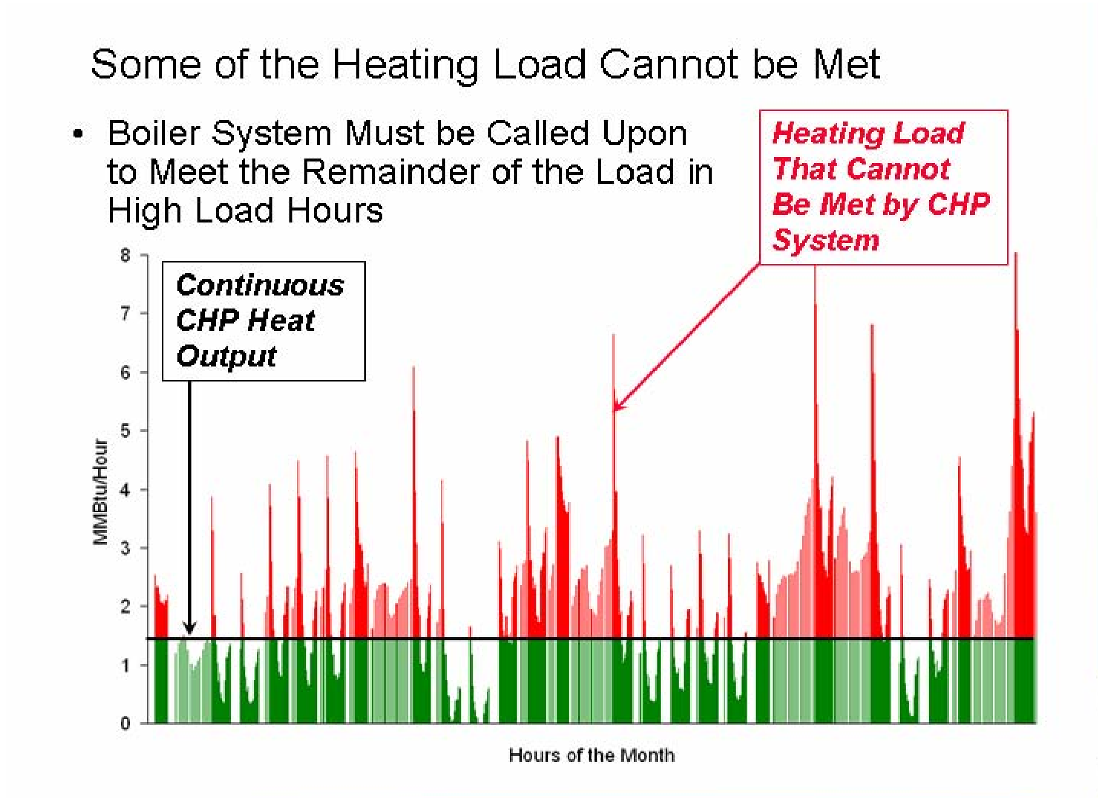
- Hour-by-Hour Heating Load (DOE-2)
- The Heating Load Varies Widely Throughout the Month

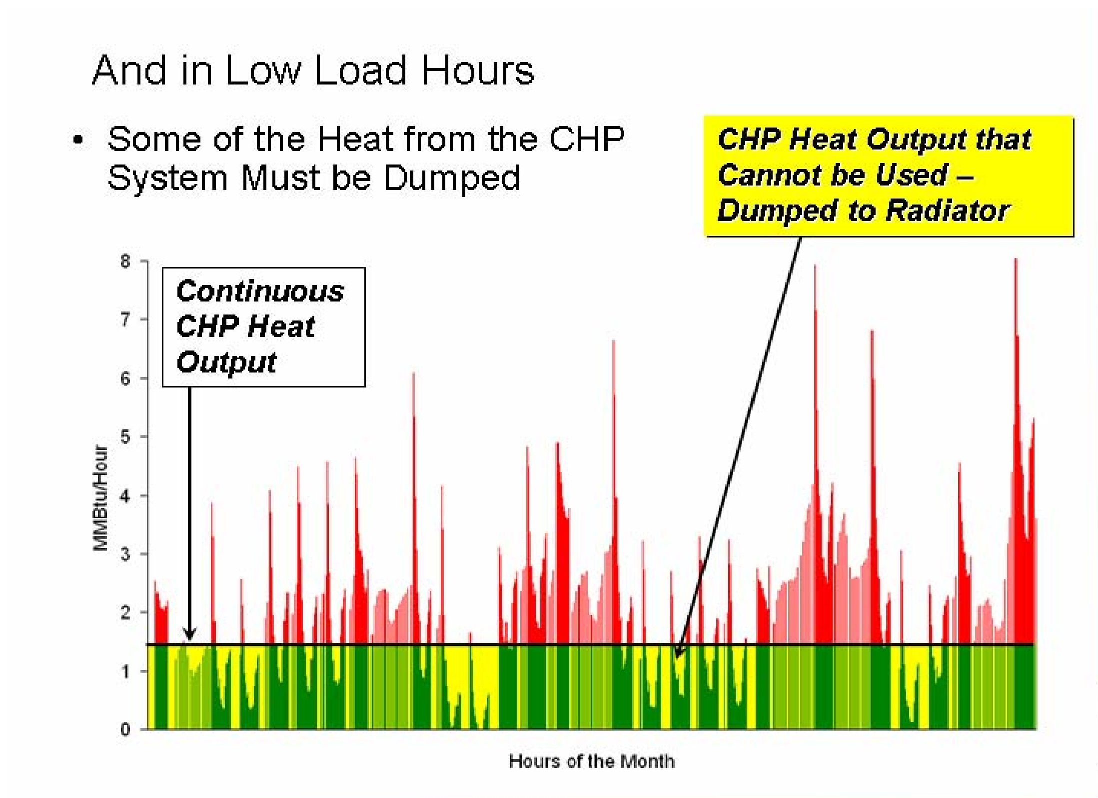


Evaluating Hour-by-Hour

- Assume CHP System Generates Constant Electric Output
- The CHP Heating Capacity Can Meet this Portion of the Heating Load




Some of the Heating Load Cannot be Met
• Boiler System Must be Called Upon to Meet the Remainder of the Load in High Load Hours
Heating Load That Cannot Be Met by CHP System
Continuous CHP Heat Output
MMBtu/Hour
0
1
2
3
4
5
6
7
8
Hours of the Month


And in Low Load Hours
• Some of the Heat from the CHP System Must be Dumped
CHP Heat Output that Cannot be Used – Dumped to Radiator
Continuous CHP Heat Output
MMBtu/Hour
0
1
2
3
4
5
6
7
8
Hours of the Month

Net Effect

- Averaging Analysis has No Choice but to Base Projections on Average Loads and Average Equipment Capacity
  - The Over-Projections Can be Quite Large
- A CHP System Following the Electric Load May Make this Worse!
  - In Commercial Building :
  - Electric Loads and Heating Loads are Negatively Correlated

	Averaging Analysis	Hour by Hour Analysis
Total December Heating Load	1088	1088
Heat Produced by CHP System	1088	1088
Load Met By CHP	1088	631
Heat Required from Boiler	0	457
CHP System Heat Dumped	0	454

Why Is This Averaging Done

- Actual Hourly Loads are Rarely Available
  - Would Not Be Useful Anyway
  - Loads Must be Corrected to Average Weather Years

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What is Needed

- Hourly Analysis Must Have an Hourly Simulation Engine (Like DOE 2)
- Problems
  - Reputation for Complexity
  - Must be Matched to Actual Building Data
- Need
  - Package That Makes This Easy to Do

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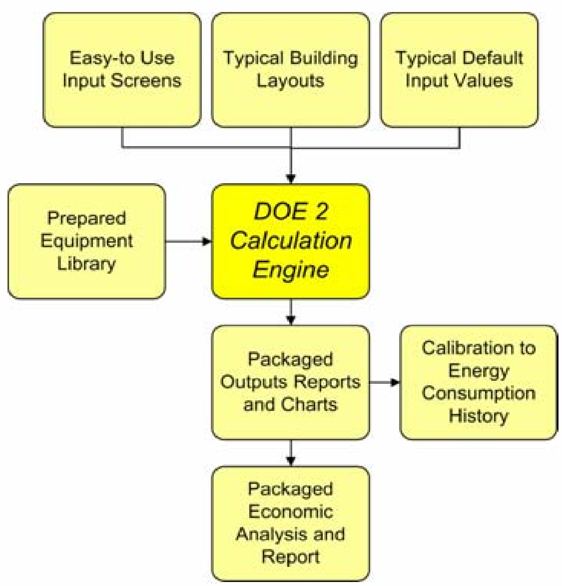
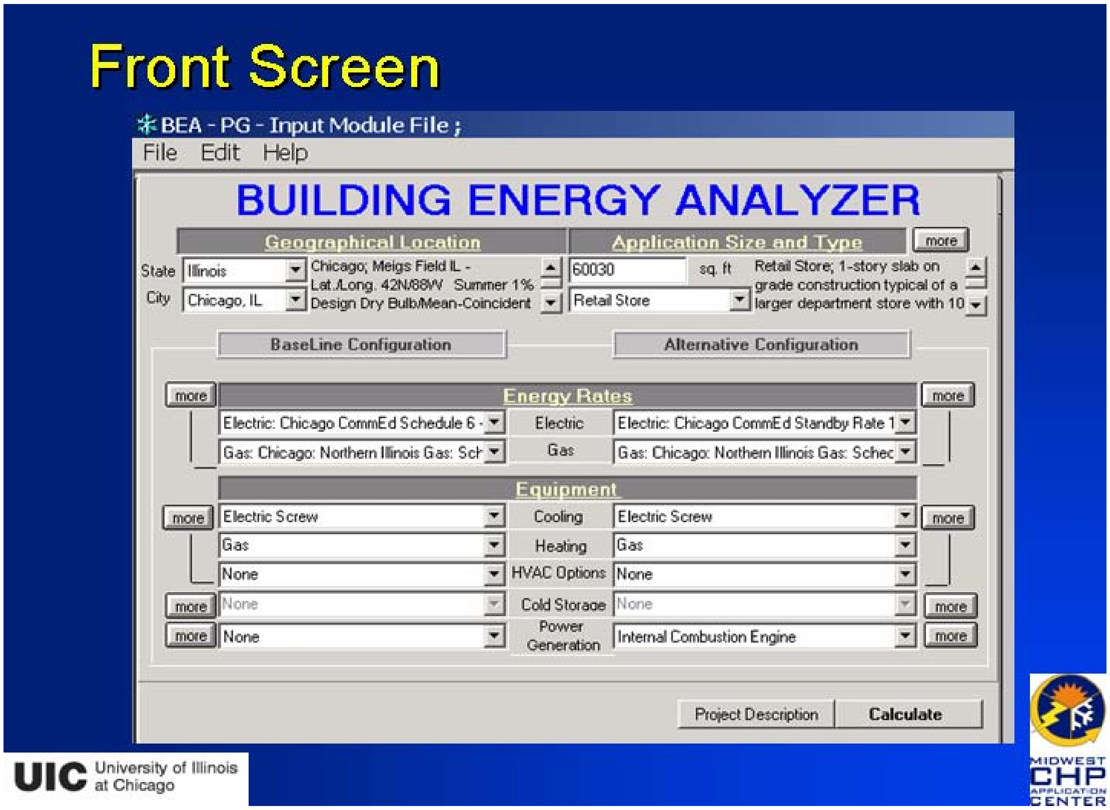
Packaged Analysis

- Hour-by Hour DOE 2 Analysis Engine
- Simple to Use Front and Back Ends
- Highly Adaptable by Adding New Equipment Components
  - DesiCalc 1997
  - Gas Cooling Guide 1999
  - Building Energy Analyzer 2002




Front Screen
BEA - PG - Input Module File ;
File Edit Help
BUILDING ENERGY ANALYZER
Geographical Location
Application Size and Type
more
State Illinois
City Chicago, IL
Chicago; Meigs Field IL - Lat./Long. 42N/88W Summer 1% Design Dry Bulb/Mean-Coincident
60030 sq. ft
Retail Store
Retail Store; 1-story slab on grade construction typical of a larger department store with 10
BaseLine Configuration
Alternative Configuration
Energy Rates
Electric: Chicago CommEd Schedule 6 -
Electric
Electric: Chicago CommEd Standby Rate 1
Gas: Chicago: Northern Illinois Gas: Sch
Gas
Gas: Chicago: Northern Illinois Gas: Schec
Equipment
Electric Screw
Cooling
Electric Screw
Gas
Heating
Gas
None
HVAC Options
None
None
Cold Storage
None
None
Power Generation
Internal Combustion Engine
Project Description
Calculate
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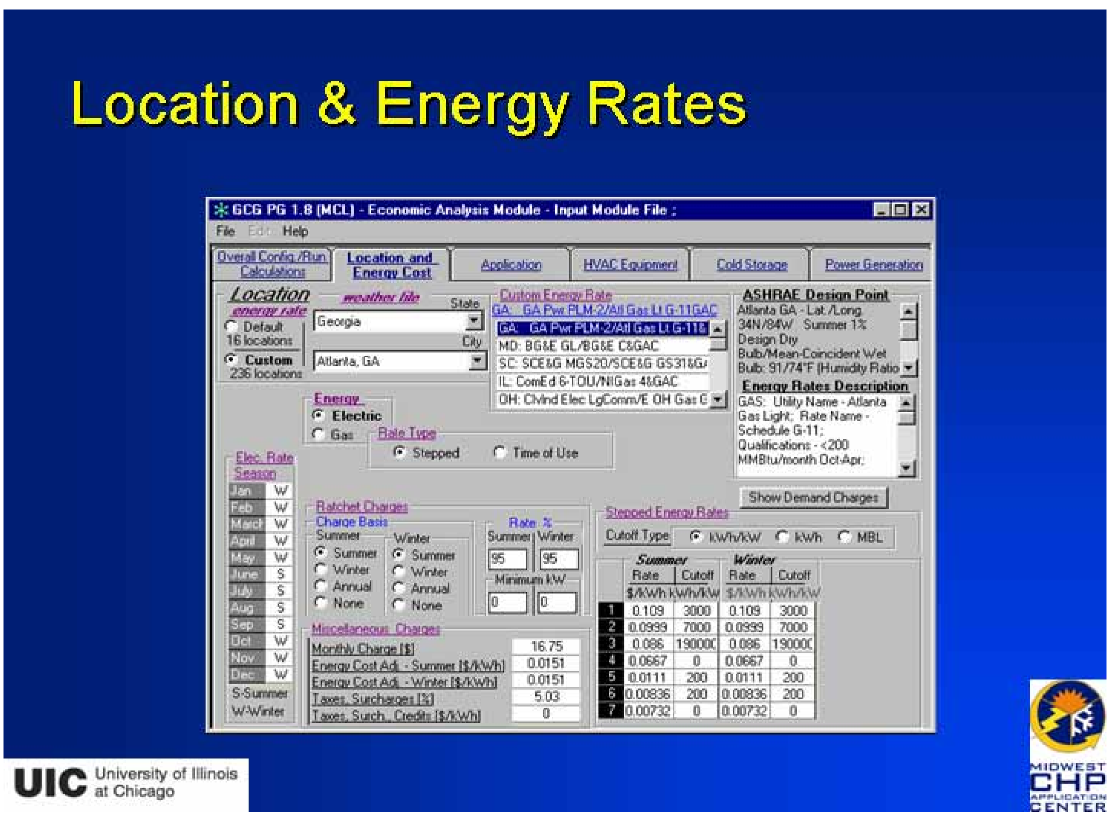
Location & Energy Rates
GCG PG 1.8 (MCL) - Economic Analysis Module - Input Module File ;
File Edit Help
Overall Config./Run Calculations
Location and Energy Cost
Application
HVAC Equipment
Cold Storage
Power Generation
Location
weather file
energy rate
Default 16 locations
Custom 236 locations
State Georgia
City Atlanta, GA
Custom Energy Rate
GA: GA Pwr PLM-2/All Gas Lt G-11GAC
MD: BG&E GL/BG&E C&GAC
SC: SCE&G MGS20/SCE&G GS31&G
IL: ComEd 6-TOU/NIGas 4&GAC
OH: Clvlnd Elec LgComm/E OH Gas G
ASHRAE Design Point
Atlanta GA - Lat./Long. 34N/84W Summer 1% Design Dry Bulb/Mean-Coincident Wet Bulb: 91/74°F (Humidity Ratio
Energy Rates Description
GAS: Utility Name - Atlanta Gas Light; Rate Name - Schedule G-11; Qualifications - <200 MMBtu/month Oct-Apr;
Energy
Electric
Gas
Rate Type
Stepped
Time of Use
Elec. Rate Season
Jan W
Feb W
March W
April W
May W
June S
July S
Aug S
Sep S
Oct W
Nov W
Dec W
S-Summer
W-Winter
Ratchet Charges
Charge Basis
Summer
Winter
Rate %
Summer Winter
95 95
Minimum kW
0 0
Show Demand Charges
Stepped Energy Rates
Cutoff Type kWh/kW kWh MBL
Summer Winter
Rate $/kWh
Cutoff kWh/kW
1 0.109 3000 0.109 3000
2 0.0999 7000 0.0999 7000
3 0.086 19000 0.086 19000
4 0.0667 0 0.0667 0
5 0.0111 200 0.0111 200
6 0.00836 200 0.00836 200
7 0.00732 0 0.00732 0
Miscellaneous Charges
Monthly Charge [$] 16.75
Energy Cost Adj. - Summer [$/kWh] 0.0151
Energy Cost Adj. - Winter [$/kWh] 0.0151
Taxes, Surcharges [%] 5.03
Taxes, Surch., Credits [$/kWh] 0
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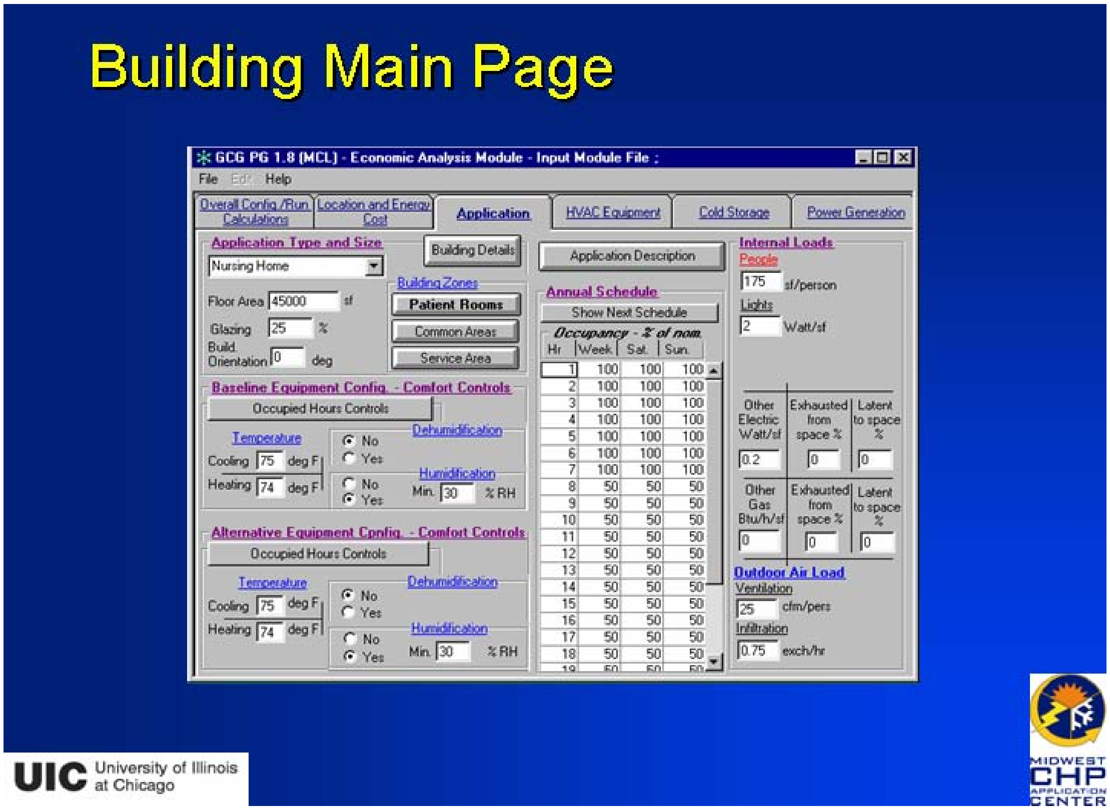
Building Main Page
GCG PG 1.8 (MCL) - Economic Analysis Module - Input Module File :
File Edit Help
Overall Config./Run Calculations
Location and Energy Cost
Application
HVAC Equipment
Cold Storage
Power Generation
Application Type and Size
Building Details
Application Description
Internal Loads
Nursing Home
Floor Area
Glazing
Build. Orientation
Building Zones
Patient Rooms
Common Areas
Service Area
Annual Schedule
Show Next Schedule
Occupancy - % of nom.
Baseline Equipment Config. - Comfort Controls
Occupied Hours Controls
Temperature
Dehumidification
Humidification
Alternative Equipment Config. - Comfort Controls
Outdoor Air Load
Ventilation
Infiltration
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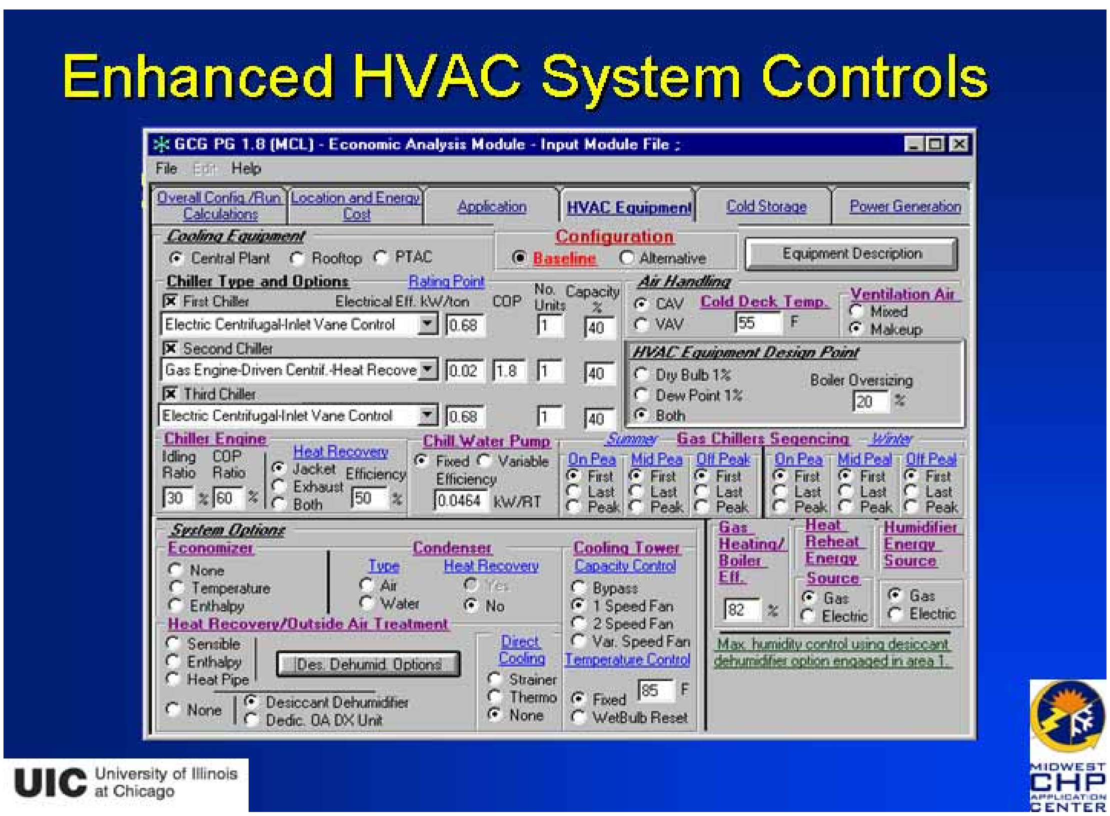
Enhanced HVAC System Controls
GCG PG 1.8 (MCL) - Economic Analysis Module - Input Module File :
File Edit Help
Overall Config./Run Calculations
Location and Energy Cost
Application
HVAC Equipment
Cold Storage
Power Generation
Cooling Equipment
Configuration
Baseline
Alternative
Equipment Description
Chiller Type and Options
Rating Point
Air Handling
Cold Deck Temp.
Ventilation Air
First Chiller
Electric Centrifugal-Inlet Vane Control
Second Chiller
Gas Engine-Driven Centrif.-Heat Recove
Third Chiller
HVAC Equipment Design Point
Boiler Oversizing
Chiller Engine
Heat Recovery
Chill Water Pump
Summer
Gas Chillers Sequencing
Winter
System Options
Economizer
Condenser
Cooling Tower
Gas Heating/Boiler Eff.
Heat Reheat Energy Source
Humidifier Energy Source
Heat Recovery/Outside Air Treatment
Des. Dehumid. Options
Direct Cooling
Temperature Control
Capacity Control
Max. humidity control using desiccant dehumidifier option engaged in area 1.
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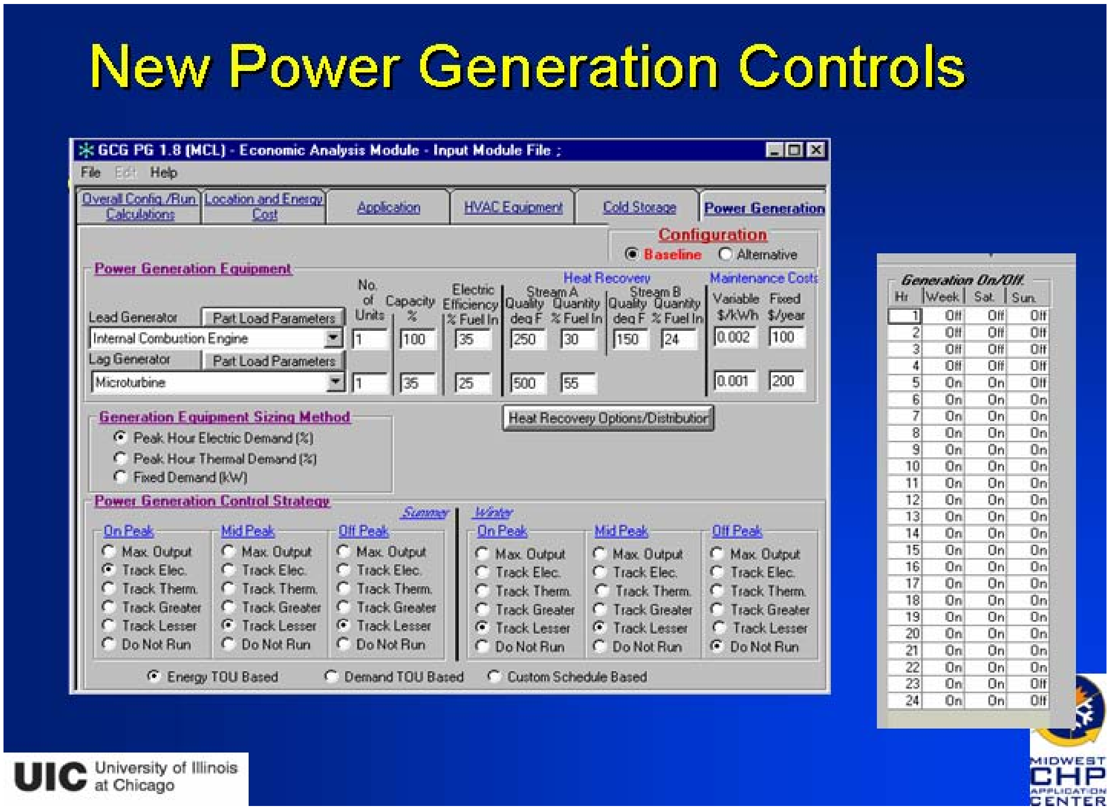
New Power Generation Controls
GCG PG 1.8 (MCL) - Economic Analysis Module - Input Module File ;
File Edit Help
Overall Config./Run Calculations
Location and Energy Cost
Application
HVAC Equipment
Cold Storage
Power Generation
Configuration
Baseline
Alternative
Power Generation Equipment
Lead Generator
Part Load Parameters
Internal Combustion Engine
Lag Generator
Microturbine
No. of Units
Capacity %
Electric Efficiency % Fuel In
Heat Recovery
Stream A Quality deg F
Quantity % Fuel In
Stream B Quality deg F
Quantity % Fuel In
Maintenance Costs
Variable $/kWh
Fixed $/year
Heat Recovery Options/Distribution
Generation Equipment Sizing Method
Peak Hour Electric Demand (%)
Peak Hour Thermal Demand (%)
Fixed Demand (kW)
Power Generation Control Strategy
Summer
Winter
On Peak
Mid Peak
Off Peak
Max. Output
Track Elec.
Track Therm.
Track Greater
Track Lesser
Do Not Run
Energy TOU Based
Demand TOU Based
Custom Schedule Based
Generation On/Off
Hr
Week
Sat.
Sun.
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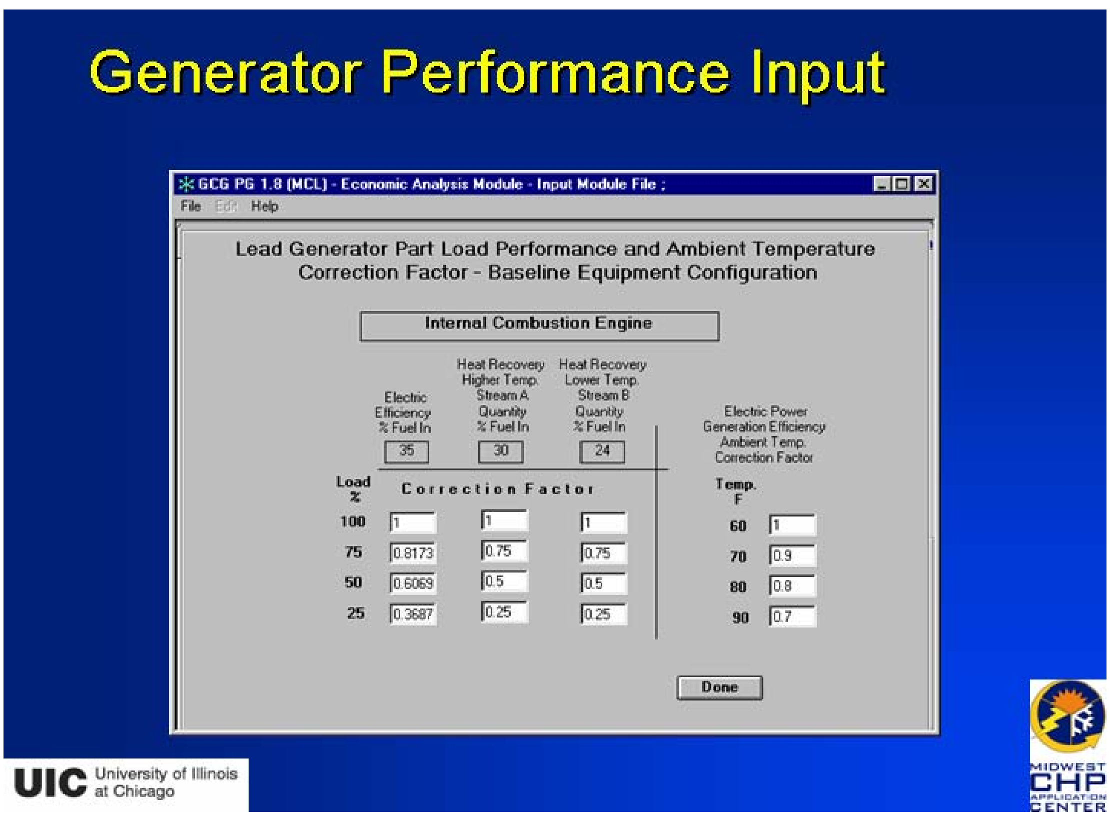
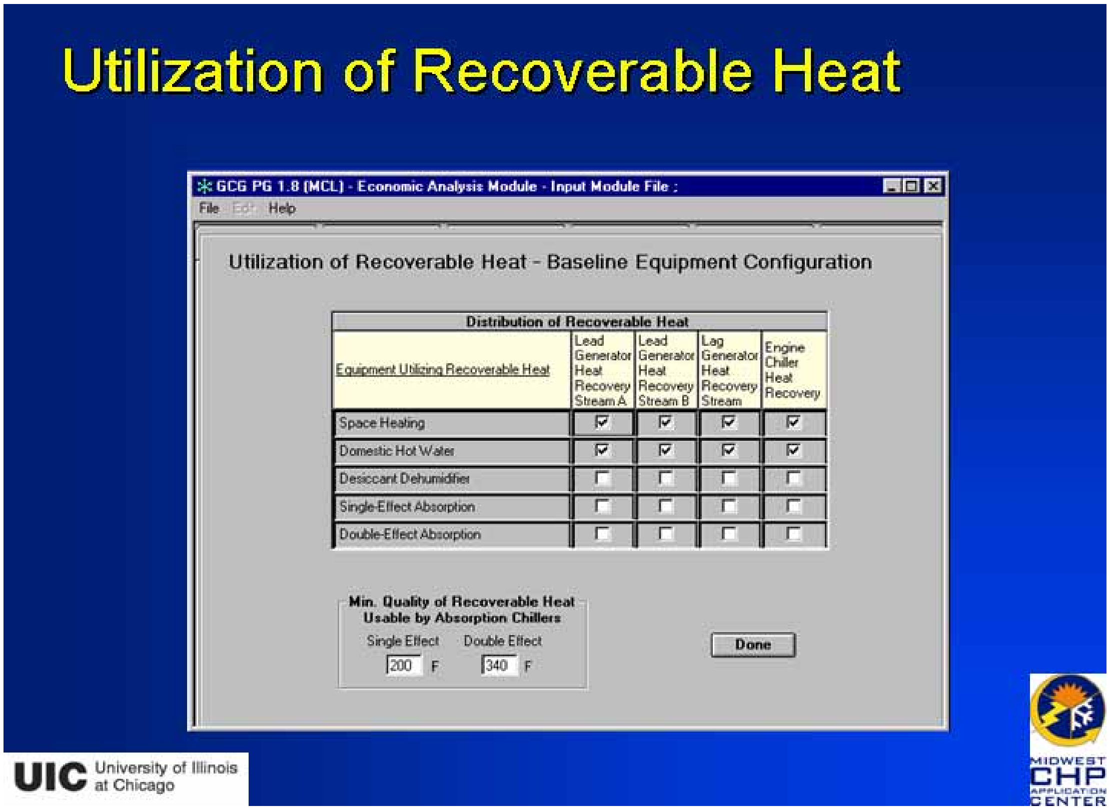

Generator Performance Input
GCG PG 1.8 (MCL) - Economic Analysis Module - Input Module File ;
File Edit Help
Lead Generator Part Load Performance and Ambient Temperature Correction Factor - Baseline Equipment Configuration
Internal Combustion Engine
Electric Efficiency % Fuel In
Heat Recovery Higher Temp. Stream A Quantity % Fuel In
Heat Recovery Lower Temp. Stream B Quantity % Fuel In
35
30
24
Load %
Correction Factor
100
75
50
25
1
0.8173
0.6069
0.3687
0.75
0.5
0.25
Electric Power Generation Efficiency Ambient Temp. Correction Factor
Temp. F
60
70
80
90
0.9
0.8
0.7
Done
UIC University of Illinois at Chicago
MIDWEST CHP APPLICATION CENTER


Utilization of Recoverable Heat
GCG PG 1.8 (MCL) - Economic Analysis Module - Input Module File :
File Edit Help
Utilization of Recoverable Heat - Baseline Equipment Configuration
Distribution of Recoverable Heat
Equipment Utilizing Recoverable Heat
Lead Generator Heat Recovery Stream A
Lead Generator Heat Recovery Stream B
Lag Generator Heat Recovery Stream
Engine Chiller Heat Recovery
Space Heating
Domestic Hot Water
Desiccant Dehumidifier
Single-Effect Absorption
Double-Effect Absorption
Min. Quality of Recoverable Heat Usable by Absorption Chillers
Single Effect
Double Effect
200 F
340 F
Done
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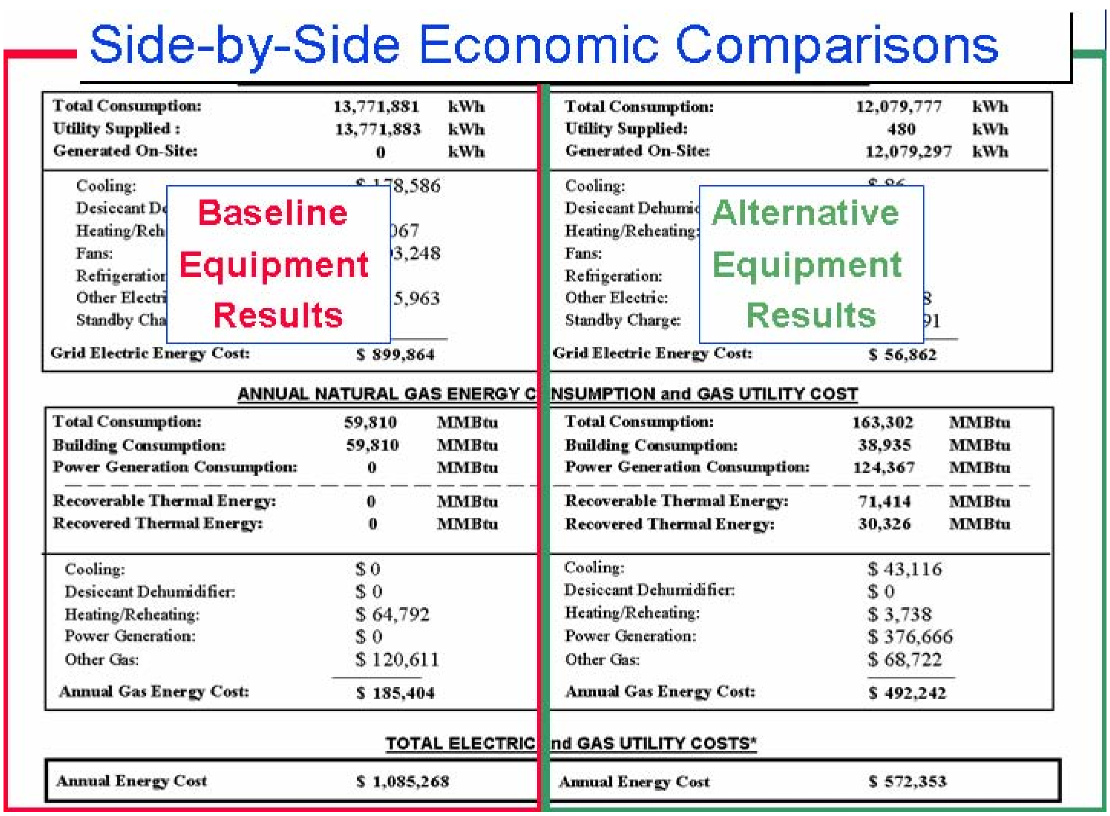
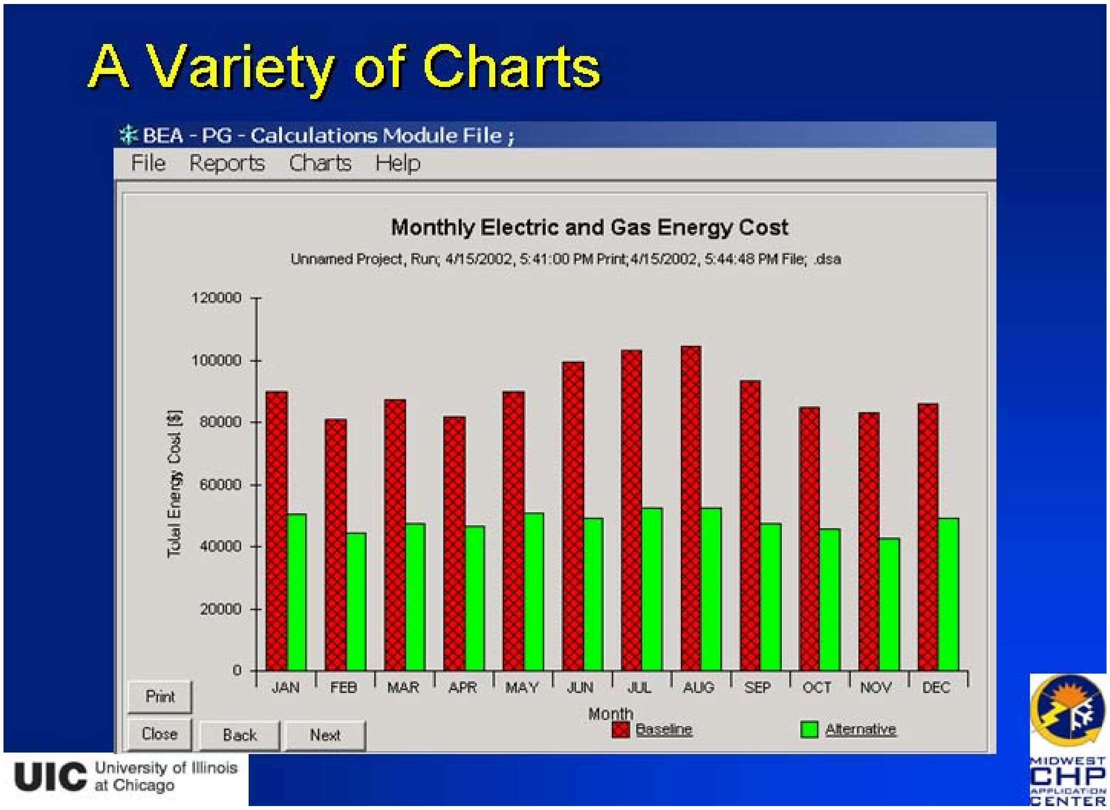

Side-by-Side Economic Comparisons
Total Consumption: 13,771,881 kWh
Utility Supplied : 13,771,883 kWh
Generated On-Site: 0 kWh
Cooling:
Grid Electric Energy Cost: $ 899,864
Baseline Equipment Results
Total Consumption: 12,079,777 kWh
Utility Supplied: 480 kWh
Generated On-Site: 12,079,297 kWh
Cooling:
Heating/Reheating:
Fans:
Refrigeration:
Other Electric:
Standby Charge:
Grid Electric Energy Cost: $ 56,862
Alternative Equipment Results
ANNUAL NATURAL GAS ENERGY C NSUMPTION and GAS UTILITY COST
Total Consumption: 59,810 MMBtu
Building Consumption: 59,810 MMBtu
Power Generation Consumption: 0 MMBtu
Recoverable Thermal Energy: 0 MMBtu
Recovered Thermal Energy: 0 MMBtu
Cooling: $ 0
Desiccant Dehumidifier: $ 0
Heating/Reheating: $ 64,792
Power Generation: $ 0
Other Gas: $ 120,611
Annual Gas Energy Cost: $ 185,404
Total Consumption: 163,302 MMBtu
Building Consumption: 38,935 MMBtu
Power Generation Consumption: 124,367 MMBtu
Recoverable Thermal Energy: 71,414 MMBtu
Recovered Thermal Energy: 30,326 MMBtu
Cooling: $ 43,116
Desiccant Dehumidifier: $ 0
Heating/Reheating: $ 3,738
Power Generation: $ 376,666
Other Gas: $ 68,722
Annual Gas Energy Cost: $ 492,242
TOTAL ELECTRIC nd GAS UTILITY COSTS*
Annual Energy Cost $ 1,085,268
Annual Energy Cost $ 572,353


A Variety of Charts
BEA - PG - Calculations Module File ;
File Reports Charts Help
Monthly Electric and Gas Energy Cost
Unnamed Project, Run; 4/15/2002, 5:41:00 PM Print;4/15/2002, 5:44:48 PM File; .dsa
Total Energy Cost [$]
120000
100000
80000
60000
40000
20000
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Month
Baseline
Alternative
Print
Close
Back
Next
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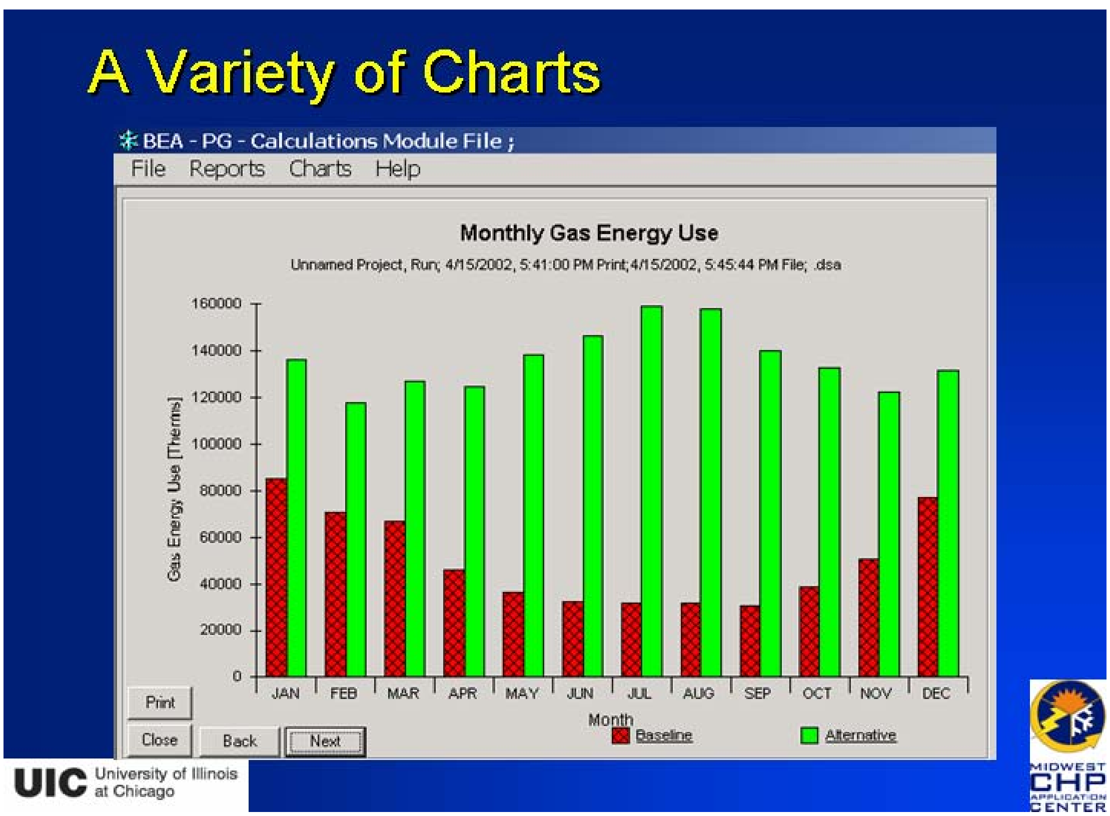
A Variety of Charts
BEA - PG - Calculations Module File ;
File Reports Charts Help
Monthly Gas Energy Use
Unnamed Project, Run; 4/15/2002, 5:41:00 PM Print;4/15/2002, 5:45:44 PM File; .dsa
Gas Energy Use [Therms]
160000
140000
120000
100000
80000
60000
40000
20000
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Month
Baseline
Alternative
Print
Close
Back
Next
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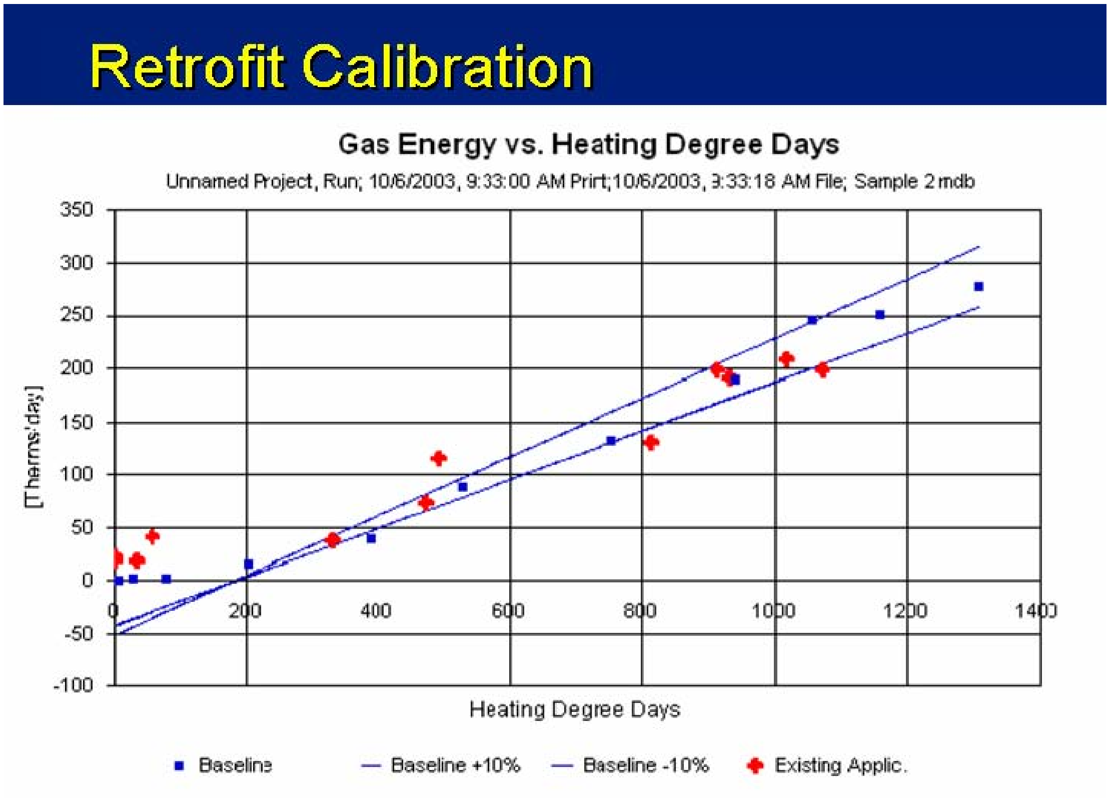
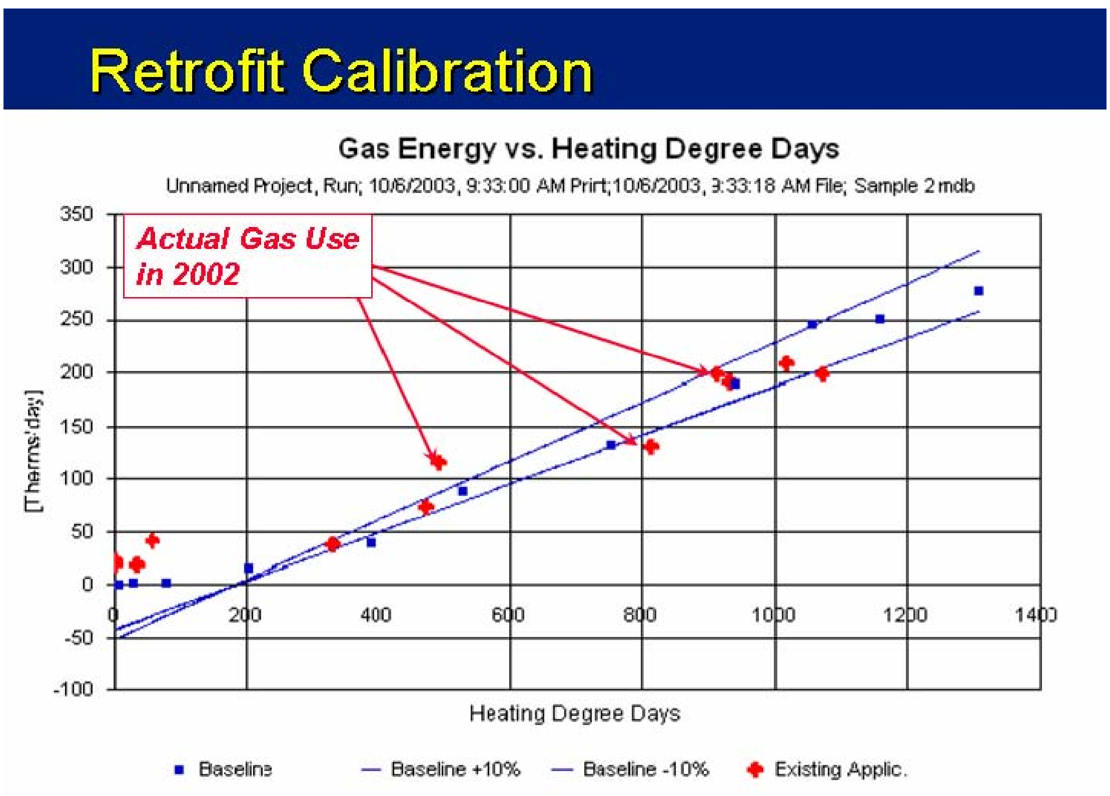
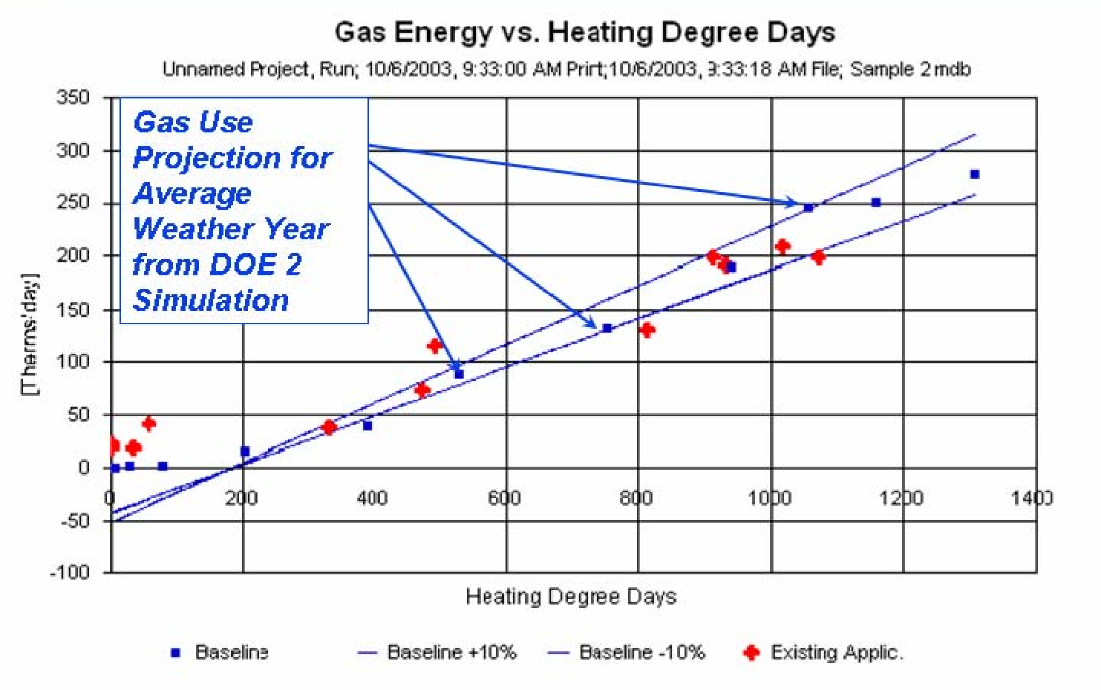
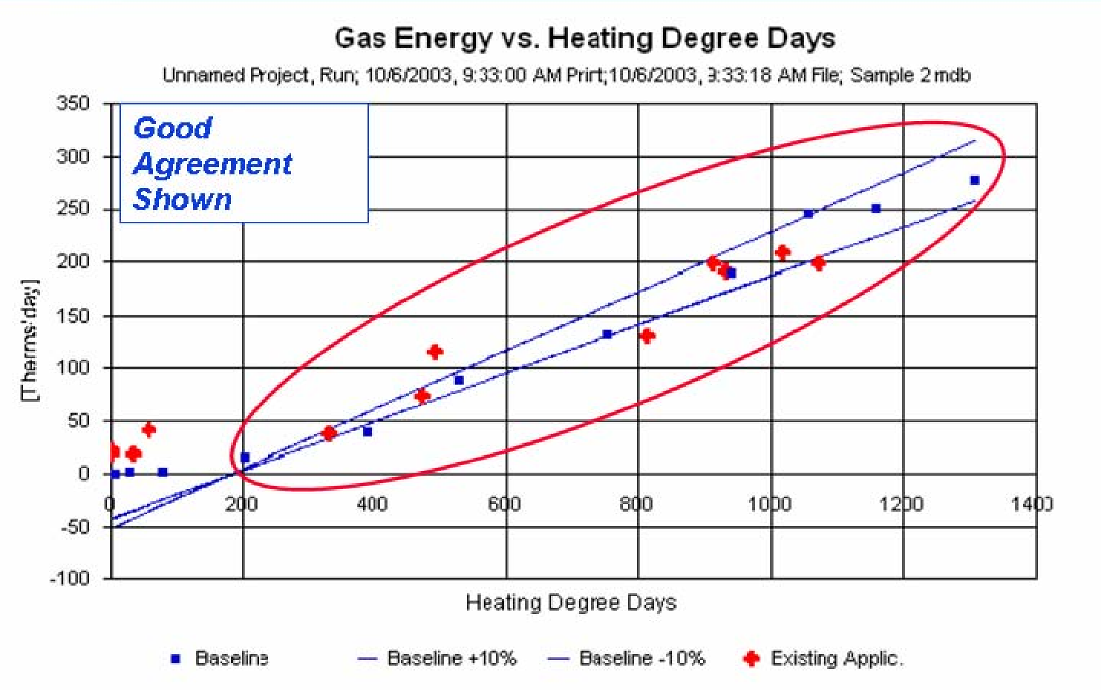

Retrofit Calibration
Gas Energy vs. Heating Degree Days
Unnamed Project, Run; 10/6/2003, 9:33:00 AM Print;10/6/2003, 3:33:18 AM File; Sample 2 mdb
[Therms/day]
Heating Degree Days
Baseline
Baseline +10%
Baseline -10%
Existing Applic.


Retrofit Calibration
Gas Energy vs. Heating Degree Days
Unnamed Project, Run; 10/6/2003, 9:33:00 AM Print;10/6/2003, 3:33:18 AM File; Sample 2 mdb
Actual Gas Use in 2002
[Therms/day]
Heating Degree Days
Baseline
Baseline +10%
Baseline -10%
Existing Applic.

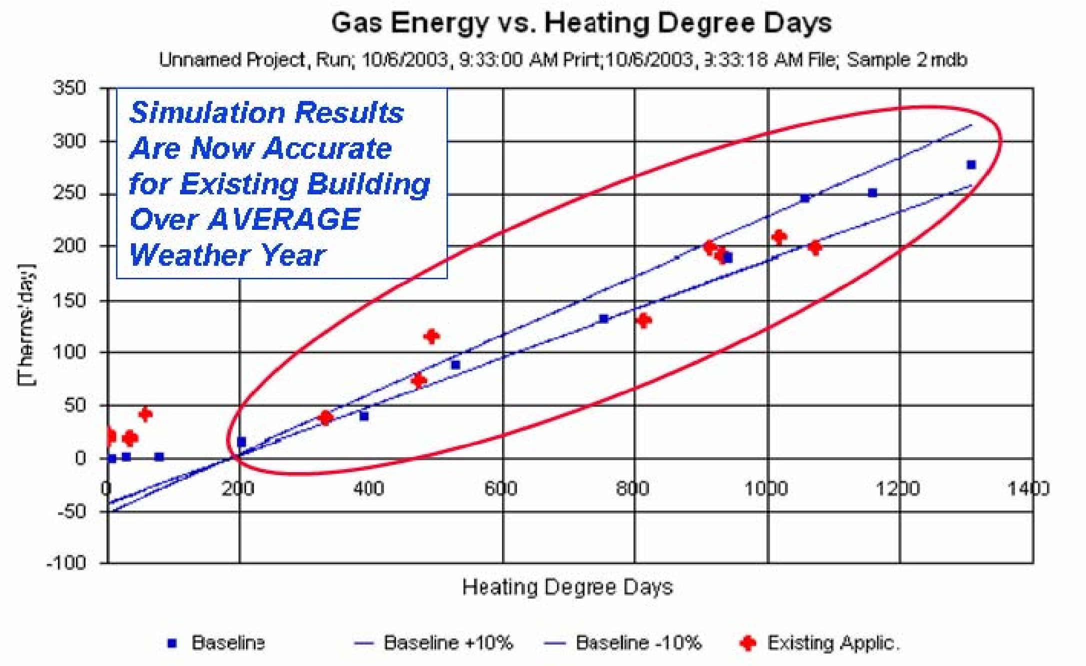
Retrofit Calibration



Retrofit Calibration



Retrofit Calibration



Does This Cover All CHP Needs

- No
  - Easy to Use Screening Tools for the Design Engineer Use “Hard” Programming to Allow “Easy” Operation
  - Set Up for Conventional Systems
- For Research
  - Need “Soft” Programmed Tools for “Easy” Modification
  - “Hard” to Use
  - Must Still Feature Hour-by Hour Operating Systems

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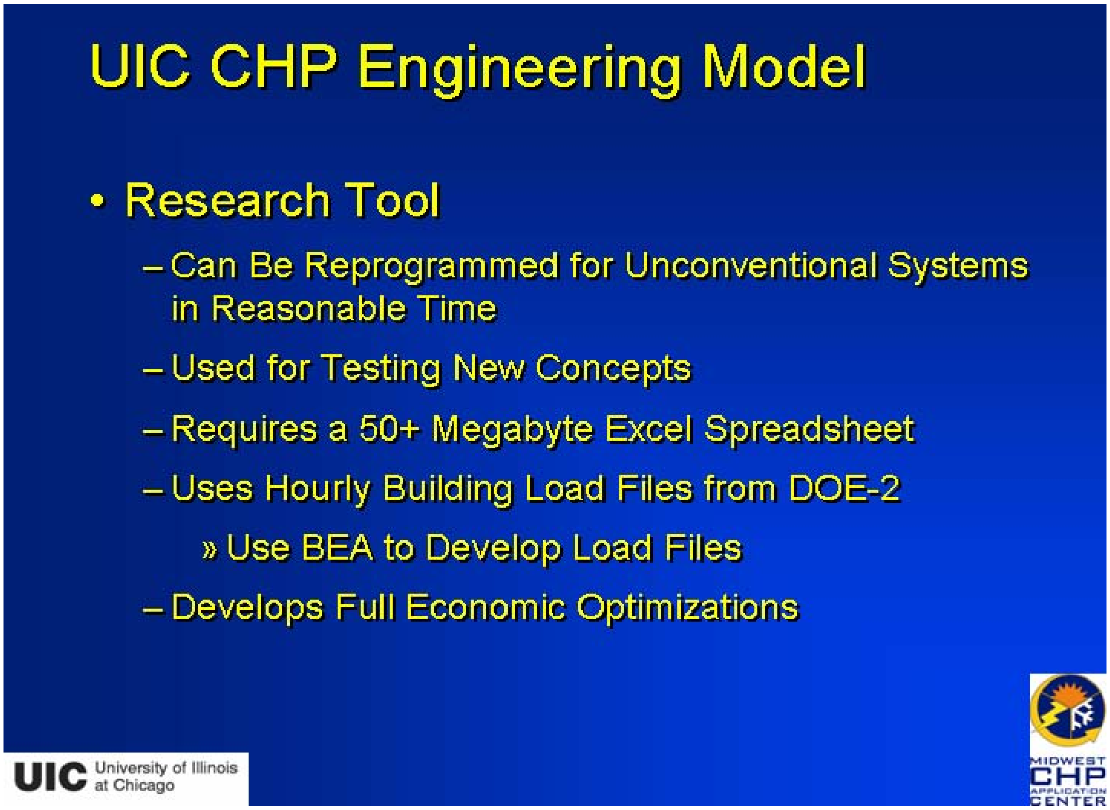
UIC CHP Engineering Model
• Research Tool
– Can Be Reprogrammed for Unconventional Systems in Reasonable Time
– Used for Testing New Concepts
– Requires a 50+ Megabyte Excel Spreadsheet
– Uses Hourly Building Load Files from DOE-2
» Use BEA to Develop Load Files
– Develops Full Economic Optimizations
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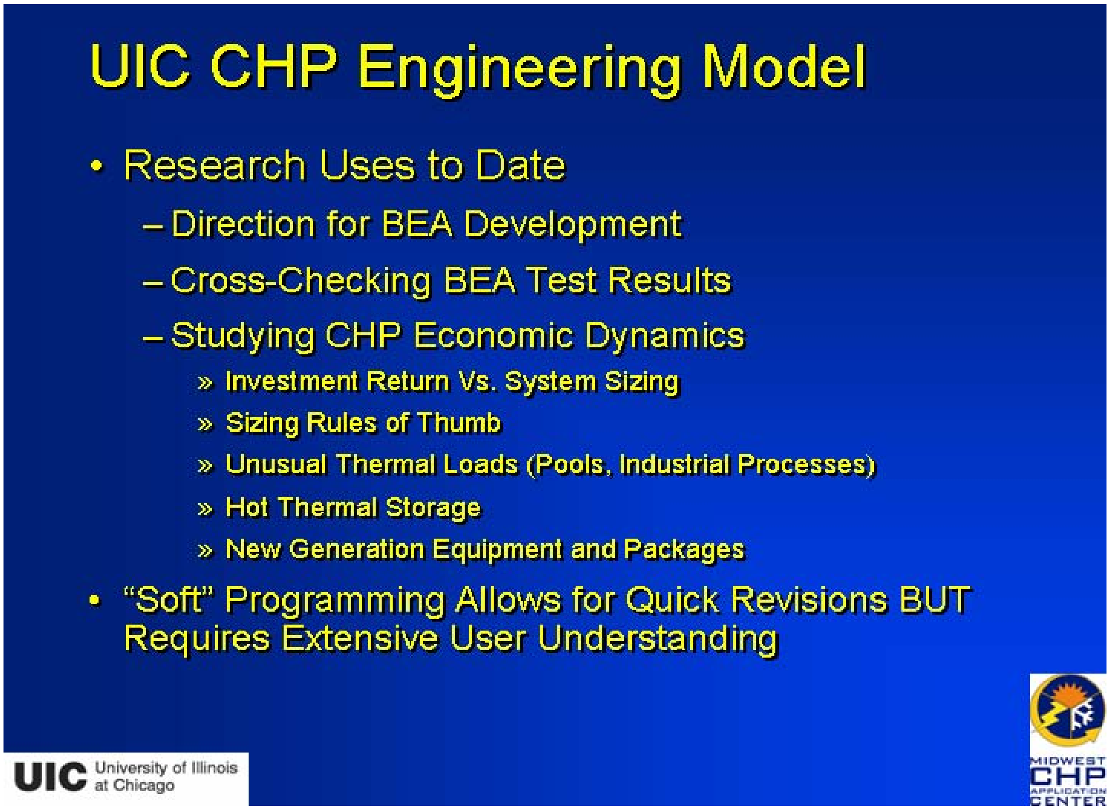
UIC CHP Engineering Model
• Research Uses to Date
– Direction for BEA Development
– Cross-Checking BEA Test Results
– Studying CHP Economic Dynamics
» Investment Return Vs. System Sizing
» Sizing Rules of Thumb
» Unusual Thermal Loads (Pools, Industrial Processes)
» Hot Thermal Storage
» New Generation Equipment and Packages
• "Soft" Programming Allows for Quick Revisions BUT Requires Extensive User Understanding
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Summary

- Screening Tools Have Advanced Considerably
- New Construction: Can Produce Economic Estimates from Preliminary Design Information
  - Allows Economics to be Scoped Early in the Design
  - Improves Chances of CHP Being Used
- Retrofits: Allow Fitting to Usage History
  - Calibrates Simulation to Real Utility History
  - Normalizes Results to AVERAGE Weather Years
    - » Very Important for Guaranteed Savings Financing

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References

- Picture Credits
  - Wartzilla
  - Solar Power Ventures
- More Information
  - Building Analyzer Program - Available from GTI

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Assessment of HVAC systems reliability

Presenter: Dr. Eugene Shilkrot. Central Research Institute for Industrial Buildings, Russia

EUGENE SHILKROT, Ph.D

Head of HVAC Laboratory
of Central Research Institute for Industrial Buildings,
Russia, Moscow

ANALYSIS of HVAC SYSTEMS RELIABILITY

HVAC SYSTEMS RELIABILITY –What is it?

Small special glossary

HVAC Equipment – collection of units - fans, air heaters, water heaters, coolers, pipes, ducts, controllers and etc.

ROOM – heated and ventilated (air conditioned) premises, residential dwellings, industrial shops

HVAC SYSTEM = Rooms + HVAC Equipment

HVAC SYSTEMS RELIABILITY –What is it?

Small special glossary

Indoor microclimate – indoor air temperature, radiant temperature, velocity, humidity, contaminant concentration

HVAC system reliability – conditions of HVAC system when all parameters of microclimate are within a normal range of parameters

Failure – conditions of HVAC system when one or all of the parameters of the microclimate are out of a normal range

HVAC system reliability depends on its power, equipments quality and level of maintenance

HVAC system reliability is calculated as probability quantity

$$P_{en.source} \equiv 1$$

$$P_{(z)} = P_{zp.out} P_{equip}$$

$P_{(z)}$ - Total HVAC system reliability

$P_{zp.out}$ - HVAC system reliability with respect to outdoor climate

P_{equip} - HVAC equipment reliability

$$P_{eq} = \prod_{n}^{m} P_i$$

$$P_i \ldots . P_{fan} \ldots . P_{airheater} \ldots . P_{cooler} \ldots . etc$$

$$P_i = \exp(-\lambda z)$$

$$\lambda = \frac{1}{z_{mean}} = const$$

$$Z_{time,hr}$$

HVAC systems are systems with temporal redundancy

Temporal redundancy is dependent upon room's inertia

Change in room's temperature in case of HVAC equipment "Failure"

$$\theta = \frac{(t_{in} - t_{out})_z}{(t_{in} - t_{out})_o}$$

$$\theta = \exp\left(-\frac{qz}{w}\right)$$

$$1(10^{-3}) \le \frac{q}{w} \le 6(10^{-3})$$

Change of room's contaminant concentration in case of HVAC equipment "Failure"

$$z = \frac{1}{k_{exh}} \ln \frac{Q_{vent} c_1 - G_{pol}}{Q_{vent} c_2 - G_{pol}}$$

$$k_{exh} = \frac{Q_{vent}}{V_{room}}$$

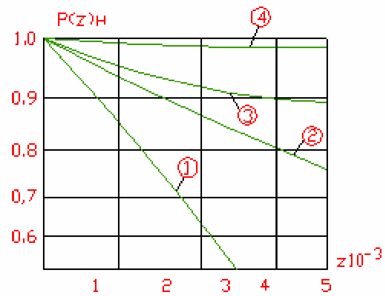
HVAC system reliability with temporal redundancy of HVAC equipment

$$P_i = \exp(-\lambda z)$$

$$\lambda = \frac{1}{z_{mean.\Delta z}}$$

$$z_{mean.\Delta z} \approx z_{mean} \exp\left(\frac{\Delta z}{z_{repair}}\right)$$

Reliability of air heating system with temporal redundancy



1- Reliability of a system without temporal redundancy

2- Reliability of a system without temporal redundancy – two heaters

3- Reliability of a system with temporal redundancy, $\Delta z = 3$hr

4- Reliability of a system with temporal redundancy, $\Delta z = 10$hr

Conclusions

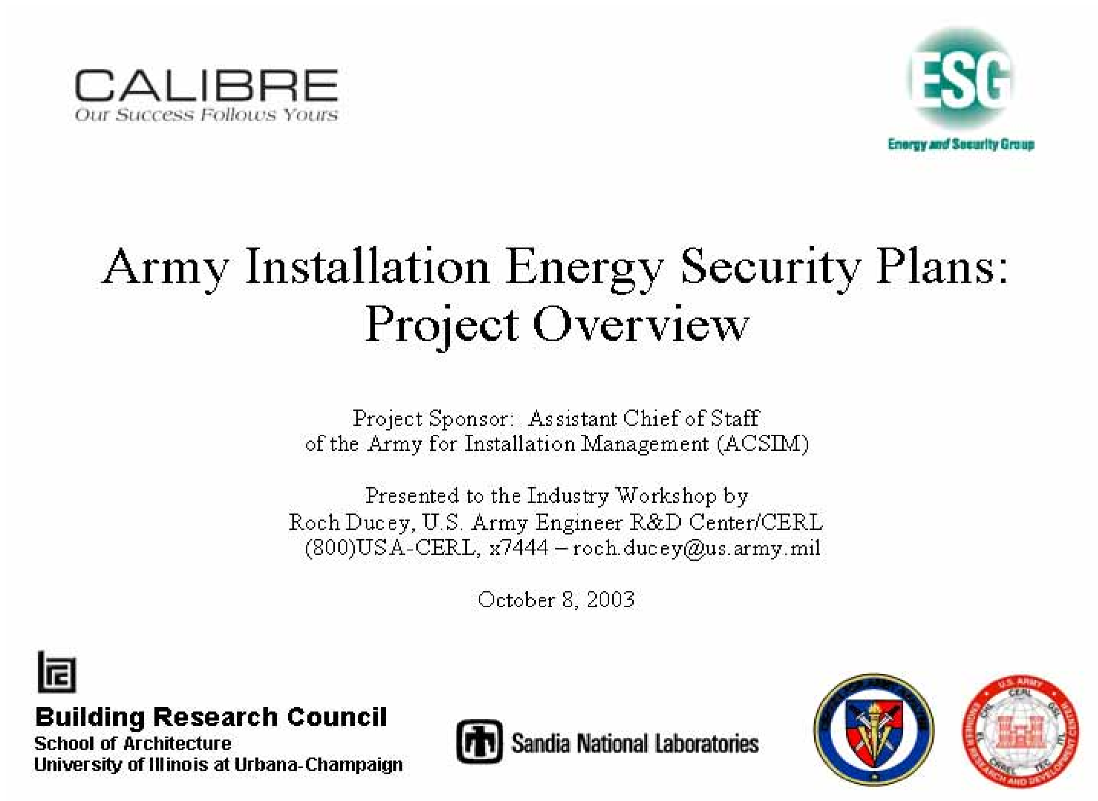
Ccalculations of reliability of HVAC systems provides an opportunity to choose optimal system design and predict expenses on system maintenance.

Calculations of redundancy time of HVAC systems provides an opportunity to estimate the number of required maintenance personnel.

Calculations of redundancy time of HVAC systems provides an opportunity to choose the optimal algorithms of operation and to minimize expenses.

Energy Security

Presenter: Mr. Roch Ducey. ERDC-CERL



Background

- Energy for training, mobilization and deployment, and other key Army missions should be available at installations when needed
- Power outages either due to an attack on a power plant or an installation (or due to any other reason) should not affect the Army's ability to perform its key missions
- The Army wants to increase energy independence and security at its installations

2

Project Purpose

- Develops Energy Security Plans for three Army installations with the goal of ensuring that their key energy needs can be supplied by DG that is secure and clean to the greatest extent practical.
- Establishes the analytic capability for developing and integrating feasible Army Installation Energy Security Plans for IMA (Installation Management Agency) Regions and across the US.

Goal - Installed Clean DG to meet key energy needs at Army installations

3

Scope

Technical

- Consider clean fixed and mobile DG; examples include photovoltaics, wind, biomass, fuel cells, microturbines,....

DG Investment Timeframe: 2004-10 (long range planning through 2020)

Financial

- Maximize use of private resources for DG investment

Project

- 3 major Army installations (case studies): Forts Lewis,Carson and Riley
- Study completed by end of July 03

4

Approach

- Determine clean DG technical potential
- Assess clean DG value added
- Examine finance options
- Develop Installation Energy Security Plans

5

Develop Installation Energy Security Plans

- Use optimization model to develop clean DG investment strategies for Forts Lewis, Carson, and Riley
- Integrate modeled investment strategies with assessment of issues to develop Army Installation Energy Security Plans
- Examples of issues include:

  - Installation Operations (e.g., Will workforce like DG?)
  - Finance (e.g., What kinds of business risk or opportunities might the private sector face?)
  - Institutional (e.g., Are there any effects on other Service installations?)
  - Legal (e.g., Are environmental waivers possible?)
  - Policy (e.g., Are there any security risks with the use of on site contractors?)

6

Project Team

- ACSIM/IMA-NWRO/Installations: Forts Lewis, Carson, and Riley
- Energy & Security Group (ESG)
- CALIBRE
- Engineer R&D Center/CERL
- Center for Army Analysis (CAA)
- Sandia National Lab

7

General Observations

- The three case installations and their utilities are concerned about threats to energy security - agree on DG micro grid on-site as goal
- Relationship of on-site DG and transmission/ distribution privatization needs to be addressed
- Utility resource planning process could include (and rate base) on-site DG
- How much should/will energy security cost? How much energy security is sufficient? Who should pay?
- DG options vary by installation

8

Concluding Remarks

- This project examines the pros and cons of installing clean DG at Army installations to increase energy security
- Technical data can be shared with private and public sectors - final report will be unclassified
- Questions/Comments/Suggestions?

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